22101479468

Digitized by the Internet Archive
in 2017 with funding from
Wellcome Library

https://archive.org/details/b28990833

R. F. Mackenzie. Harman
Final Year M.M.C. 24-2-04

THE ELEMENTS OF SANITARY SCIENCE.

A HAND-BOOK FOR DISTRICT, MUNICIPAL, LOCAL MEDICAL AND SANITARY OFFICERS, MEMBERS OF LOCAL BOARDS AND MUNICIPAL COUNCILS, AND OTHERS IN INDIA.

BY

SURGEON-MAJOR C. J. McNALLY, M.D., D.P.H. (CAMB.),

FELLOW OF THE MADRAS UNIVERSITY; FELLOW OF THE CHEMICAL SOCIETY; ASSOC. COLL. OF STATE MEDICINE; CHEMICAL EXAMINER TO GOVERNMENT AND PROFESSOR OF CHEMISTRY; FORMERLY PROFESSOR OF HYGIENE, MADRAS MEDICAL COLLEGE; ACTING DEPUTY SANITARY COMMISSIONER.

THIRD EDITION REVISED AND PARTLY RE-WRITTEN

BY

CAPTAIN J. W. CORNWALL, M.A., M.D. (CANTAB.),
INDIAN MEDICAL SERVICE.

HEALTH OFFICER, MADRAS MUNICIPALITY; ACTING INSPECTOR OF VACCINATION AND DEPUTY SANITARY COMMISSIONER; PROFESSOR OF HYGIENE AND PRACTICAL BACTERIOLOGY, MADRAS MEDICAL COLLEGE.

MADRAS:
THE SUPERINTENDENT, GOVERNMENT PRESS.

1903.

[PRICE, *rupees* 2 *annas* 8.]

95400

MADRAS:
PRINTED BY THE SUPERINTENDENT,
GOVERNMENT PRESS.

WELLCOME INSTITUTE
LIBRARY
Coll. welTROmec
Call No. Crawf.
Coll.
/MAC.N

A. G. Sawyer

PREFACE TO THE THIRD EDITION.

The task of revising a book written by some one else is not a particularly easy or attractive one as the standpoint of no two men can be the same as regards arrangement, and there is room for much diversity of opinion as to what is essential and what is trivial, what should be treated fully and what should be merely mentioned or entirely omitted; and it is a matter for profound regret that Surgeon-Major McNally is not alive to carry out the work with his own hands.

The book has been a great favourite with Madras students in past years, because it deals with Hygiene almost entirely from an Indian point of view, and they do not have to skip whole chapters which treat of sanitary matters according to English standards, and which are, therefore, partly unintelligible and wholly useless to them, as is the case when they possess themselves of a current English text-book. This hand-book has been out of print for some time, and the students have, consequently, had to fall back upon one of the several English manuals, which, though excellent in themselves, are for the reason given above unsuited to the needs of Indian students, particularly those who are in training for Sanitary Inspectors' certificates.

It has been difficult to decide what alterations to make besides bringing the book up to date as regards recent work, bearing in mind that it was not desirable to increase its length in any great degree. The principal changes have been made in the chapters on "Water," "Removal of waste," and "Microbic diseases," but every chapter has been carefully revised with the exception of the "Introduction" which has scarcely been touched. The Appendix on

"First Aid" has been omitted and also all the plates, which were both crude and out of date. I have preferred not to burden the book with new or stock diagrams and incidentally to increase its expense, and, instead, I would recommend students to study in connection with it "Diagrammettes (Hygiene)" by Knight, published by Chapman and Hall of London, price one shilling, which is a collection in a small compass of illustrations of the common objects of sanitary interest with detailed descriptions.

For reference I am indebted to the works of Notter and Firth, Davies, Parkes and Kenwood, and Munson, and for various suggestions, born of the experience of several years' teaching of students, to Dr. Chandrasekar Iyer of the Medical College.

MADRAS, J. W. C.
1st *July* 1903.

PREFACE TO THE FIRST EDITION.

This Hand-book is addressed primarily to the educated classes, in the hope that it may afford them information which is important to all—as life and health are important—and which may serve to benefit them, and, through them, the great uneducated masses of the people. Many persons, who are otherwise well educated, have been taught little or nothing of the science of health, and suffer individually thereby; while general sanitary authority is invested in corporations whose members often feel the need of a guide to the principles of Public Sanitation, and who are, for want of it, unable always to spend the public money to the best advantage of the public.

Those who desire to obtain more than a superficial acquaintance with the subject of Sanitary Science should begin by acquiring some knowledge of elementary chemistry, biology, and physiography.

A few portions of the book may not be so clear to those who possess no such preliminary knowledge; but the author trusts that the greater part of it may be perused with advantage even by those who have not had the benefit of any scientific training.

It has been his object to expound the *principles of sanitation* (while not omitting useful practical details, with special reference to Indian requirements), and to avoid dogmatic statements; for any appeal to educated and thoughtful men must be addressed to the intellect, and these pages are an appeal to the more educated, thoughtful, and influential members of the community to awaken to the vastly important actualities of sanitary neglect and to the immense possibilities of sanitary progress.

Authorities are generally quoted in foot-notes; statements not so authenticated are either well-known facts, or those for which the author is responsible. General acknowledgments are due to the writings of Cornish, H. King, various Sanitary Commissioners and others in India, and to those of Parkes, Farr, Simon, Buchanan, Corfield, Wilson, Klein, and many others in England, as well as to those of Pasteur, Koch, and some other foreign workers and authors.

The author is conscious of some faults in this little work, which has been put together during furlough and in the few leisure intervals of official life; many others no doubt exist of which he is not conscious. He hopes, however, that they are not such as will impair its general usefulness. Although written for the Madras Presidency, it applies equally—with the exception of parts of the chapter on *Sanitary Law* dealing with local Acts, which differ in each province—to all parts of India; and it is nearly as applicable to tropical countries generally. It may, therefore, prove of some use in England to medical and civil officers and others who are preparing to go to India or other tropical regions.

MADRAS,
October 1889.

CONTENTS.

CHAPTER I.

INTRODUCTION.

Page

Health and Disease ... 1

CHAPTER II.

FOOD AND DIET.

Physiology of Food ... 11
Constituents of Food ... 12
Requirements of Diet ... 15
Proportions of Alimentary Constituents ... 15
Quantity of Food required ... 19
Food Materials ... 23
Staple Food-grains ... 23
Leguminous Grains ... 27
Animal Foods ... 29
Oily Foods ... 32
Starches and Sugars ... 32
Vegetables and Fruits ... 33
Beverages ... 34
Rations and Dietaries ... 36
Rations for large numbers ... 43
Preservation of Food ... 43
Unwholesome Food ... 44
Adulteration of Food ... 46
Inspection of Food ... 47

CHAPTER III.

WATER.

Impurities of Water ... 54
Diseases due to Impure Water ... 56
Sources of Water ... 57
Natural Purification of Water ... 66
Artificial Purification of Water ... 67
Water-supply of Towns ... 71
Water-supply of Villages ... 75
Examination of Water ... 80
Easy method of examining Water ... 81
Complete examination of Water ... 86

CHAPTER IV.

AIR.

Composition of Air ... 91
Impurities of Air ... 92
Effects of Impure Air ... 94
Purification of Air—Ventilation—Cooling ... 95
Examination of Air and Ventilation ... 102

CHAPTER V.

Page

REMOVAL OF WASTE.
Street Sweepings 107
Disposal of Rubbish 108
Excreta 109
The Water-carriage System 112
Sewage 113
Disposal of Sewage 115
Purification and Utilisation of Sewage 116
Village Latrines 119
Covered Sewers and Sewer-drains 120
Disposal of Dead Bodies 121

CHAPTER VI.

LOCAL CONDITIONS: SOIL, CLIMATE, AND METEOROLOGY.
Soil 123
Constituents of Soil 123
Air in Soil 124
Water in Soil 125
Healthy and Unhealthy Soils 127
Improvement of Unhealthy Soils 129
Climate 131
Temperature 132
Moisture 133
Pressure 134
Wind 135
Cloud 136
Rain 136
Sun 136
Meteorology 137
The method of using Meteorological Instruments 139

CHAPTER VII.

HOUSES AND BUILDINGS 141
Preparation of Site 142
The Ground Floor 143
Walls 143
Upper Floors 145
Roofs 145
Verandahs 145
Out-houses and Stables 146
House Interiors 146
Public Buildings 147
Markets, Slaughter-houses, Cattle-yards 148
Bathing Places 149

CHAPTER VIII.

PERSONAL HYGIENE.
Habit 150
Custom 151
Cleanliness 152
Clothing 153
Exercise 155

Page
Temperance 158
Mental Hygiene 159
Marriage 160
Maternity 164
The Four Ages of Man 164
Vitality and Longevity 166

CHAPTER IX.

PREVENTION OF DISEASE—PHYSIOLOGICAL DISEASES, PARASITIC DISEASES.
Classification of Diseases 168
Physiological Diseases 169
Prevention of Physiological Diseases 170
Parasitic Diseases 170
Prevention of Parasitic Diseases 172

CHAPTER X.

MICROBIC DISEASES 177
Forms and Characters of Microbes 179
Innocent and Pathogenic Microbes 180
Susceptibility and Immunity 182
Contagion 183
Endemics and Epidemics 186
Epizootic Diseases 188
Prevention of Microbic Diseases 189
External Conditions which favour Microbic Growth 189
Bodily Conditions which favour Microbic Growth 189
Protection by Inoculation 190
Isolation of the Sick 192
Compulsory Notification 196
Disinfection 200
Practical Disinfection 203
Malaria 205
Cholera 210
Small-pox 214
Dysentery and Diarrhœa 219
Enteric or Typhoid Fever 219
Plague 220
Relapsing Fever 221
Measles and Chicken-pox 221
Tuberculosis 221
Syphilis 222
Leprosy 223

CHAPTER XI.

VITAL STATISTICS.
Preliminary considerations 225
Ratios 226
Means 228
Objects of Statistical Enquiries 230
Arrangement of Statistics 231
Population 233
Census 234

Page
Registration of Births and Deaths 242
Births 243
Deaths 247
Sickness 254
Duration of Life 254
Life Tables 254
The mean duration of life 255

CHAPTER XII.

SANITARY LAW 256
The City of Madras Municipal Act 257
The Madras District Municipalities Act 262
The Madras Local Boards Act 265
District Boards 265
Taluk Boards 265
Panchayats 265
Duties of Local Boards 266
Duties of Panchayats 266
Indian Penal Code 267
Code of Criminal Procedure 268
Public Nuisances 268

APPENDIX A.

Comparison of English and Metrical Weights and Measures ... 271

APPENDIX B.

Offensive Trades 272

INDEX 273

CHAPTER I.

INTRODUCTION.

HEALTH AND DISEASE.

GOOD health is the greatest of blessings, and is universally recognised as the one indispensable quality of happiness for animated beings. In all countries and in all conditions, inquiries after health form the habitual salutation of friends, and "health and long life" their kindest wish.

By general consent, fame, rank, wealth, and all else which men most do covet and cling to are as naught compared with health. This, then, being admittedly the most valuable of all possessions, we would naturally conclude must be the most jealously guarded and preserved by men; yet such is far from being the case. Men habitually squander health and life as though they valued these least of all things. Life is proverbially sweet, yet the great majority of mankind perish prematurely from more or less preventable disease; few die from accident or the natural decay of age. In India alone more than two millions of human lives are annually sacrificed to preventable disease and more than ten millions are rendered temporarily or permanently miserable by it.

Ignorance and apathy are the keys of this apparent contradiction—ignorance of the origin and nature of disease and of the means of preventing it; apathy, a result of poverty and debility, which holds to acquired habits, or fears the magnitude and inconvenience of reform. Few persons, even among the otherwise highly educated, truly realize the enormous amount of misery, inefficiency, and death which result from preventable disease, or credit the large degree to which individuals and communities can control their own health and happiness.

The most famous civilized nations of antiquity gave much care to sanitation in various ways, and owed not a little of their pre-eminence to this. The successes of Grecian arms and the glories of Grecian art were prepared and fostered by the great attention which the Greeks paid to physical culture. The Romans not only rivalled them in this, but in the magnificent aqueducts, sewers, and recently discovered sub-soil drains in Rome itself and in many places throughout old Roman provinces, and they have left still visible monuments of the importance which they attached to a pure and abundant supply of water, to the removal of filth and to dryness of soil. Several ancient religions and laws give other instances of practical sanitary knowledge and regulations. The fall of the Roman empire, however, followed by an era of political instability, led to a forgetfulness of the primitive laws of health and a lapse into habits of uncleanness, which fully account for the terrible habitual mortality which prevailed and the awful epidemics which periodically swept over Europe during the middle ages. Mankind had once again to be taught by dire experience, and from its teachings gradually arose the fabric of modern hygiene.

A few facts may now be cited from the recent history of England to show what can be accomplished in a comparatively short period by sanitary reform. Fifty years ago, England was little more advanced in public sanitation than India is at the present day. Impurity of air, water, and soil was the rule everywhere; vaccination was not general; sanitary law was all but unknown; no facilities existed for towns or districts to borrow capital for public improvements; there was no general registration of vital statistics. The Registration Act of 1837 was the *Magna Charta* of sanitary reform in England, and the able and logical reports of the Registrar-General (Dr. Farr's first annual report appeared in 1839) did more than anything else to place England in the foremost-rank of healthy nations. Activity in the prosecution of sanitary works became prevalent all over the country, and the good effect of measures, such as improvements in drainage, sewerage, water-supply, food, dwellings, is abundantly shown by the great and progressive decline of mortality which immediately followed them. Numerous instances are cited in the reports of the Registrar-General and of the Medical officers of the Local Government Board, which show that such a local decline invariably followed local sanitary improvements. The money borrowed for sanitary works in Great Britain between 1848 and 1886 amounted to no less than £130,000,000, in addition to large sums provided out of local revenues and enormous private expenditure. But this money was well invested. The average duration of human life in Great Britain has been largely increased,* and this, coupled with the prevention of sickness, has added enormously to the productive power of the population and the wealth of the nation. The yearly death-rate of London, which closely approaches the average English death-rate and was 50 per 1,000 in the past century, steadily diminished until it reached but 22·4 in the ten years 1871–80 and 19·3 in the five years 1881–85, and several English districts have now a death-rate below 15 per 1,000—a rate which was not long since regarded as utopian. Considering the amount of preventable disease which still exists and the amount of sanitary work which is practicable in the way of improving local conditions and habits and preventing the spread of disease, it must be regarded as possible for the mortality of the United Kingdom as a whole to be still further reduced.

Similar results can undoubtedly be attained in India, and India has this general advantage over England, that she possesses proportionately few large towns. The introduction of purer water-supplies has caused a large reduction of cholera mortality in Madras, Calcutta, and some other towns; the great improvement of health among soldiers and prisoners in cases where a faulty dietary has been corrected is well known; and other instances might be mentioned where sanitary measures have been followed by a reduction of mortality in India.

It has been reckoned that nearly four-fifths of the entire registered mortality of India is due to mitigable or preventable diseases.† The statistics of the general population are unreliable owing to imperfect registration, but those of municipal towns are more to be depended on. In the municipal towns of the Madras Presidency for the five years 1881–1885 the average registered annual mortality exceeded 30 ‡ per 1,000, and nearly half of this mortality was attributed to the four causes—cholera, small-pox, fevers, and bowel-complaints; the first two of which ought to be entirely preventable and the two latter preventable to a great extent. Besides these, other preventable diseases account for a portion of the remaining mortality. Altogether there is no doubt that Indian mortality can be very largely reduced and that the happiness and prosperity of the people will increase with their longevity. It is necessary, however, that the excessive birth-rate should be reduced at the same time; this subject will be treated of in several places further on.

---

* The mean duration of life (expectation of life at birth) was, in round numbers, by Price's Northampton Life Table corrected (1762) about 30 years, by Milne's Carlisle Table (1789) 38 years, by Farr's English Life Table, No. 1, (1841) 41 years, and by Dr. Ogle's New English Table (1871–80) 43 years. It is now considerably longer.

† Army Sanitary Commission, 1886.

‡ The true rate was probably about 40.

Poverty is undoubtedly a great bar to sanitary improvement, and bad sanitary conditions beget poverty, so that poverty and sickness re-act upon each other and tend to diminish the vital power of a people and their capacity for improvement. Hence the task of initiating sanitary improvements must devolve upon the governing, educated, and wealthy classes of a community; and, apart from the higher motive of philanthropic duty in relieving the sufferings and ameliorating the lot of their poorer, more ignorant and dependent brethren, it is manifestly their personal interest to ward off disease from their own doors. Not rarely do epidemic diseases, such as cholera or small-pox, whose breeding places are in the midst of dirt and poverty, leave their endemic haunts among the poor and seek out their victims in the neighbouring houses of rank and opulence. Then, indeed, spasmodic efforts are inspired by terror, and money is often frittered away in fruitless efforts to stay an epidemic, which wiser forethought would have prevented.

Such hurried whitewashing and cleaning up can do little to purify places, where earth, water, and air have been habitually defiled, to establish effective control over unwholesome food supplies, or to reform the insanitary habits of generations. Deliberate training and preparation are as necessary to protect a country against the invasions of disease as to fortify it against the inroads of an enemy, and all experience proves that sanitary preparations protect from endemic as well as from epidemic diseases. Sanitary preparations should, therefore, be steadily prosecuted at all times, and we may rest assured that as we lessen our mortality from ordinary endemic diseases, so do we diminish our liability to the ravages of epidemics; but, while urging that sanitary improvement should be prosecuted steadily at all times and not only fitfully under the influence of panic produced by unusual outbreaks of disease, it should not be forgotten that it is a wise axiom not to destroy existing arrangements, faulty though they may be, without having provided efficient substitutes.

The duties of the sanitarian require a combination of reason and firmness, tact and skill. It is only by earnest and sustained exertion that any permanent improvement can be effected, and constant vigilance is required to prevent deterioration and relapse. Unwearying attention to details is a necessary condition of success in sanitary administration, and the most indomitable perseverance is needful for the pioneers of sanitary work. Zeal must, however, be tempered with discretion, and, in dealing with ignorant or interested opposition, tact and compromise may largely succeed when haste and impracticable thoroughness must totally fail. Small and partial measures can often be carried out where larger and more comprehensive ones are impossible, and small and partial measures of improvement are not by any means useless. They are steps on the road. Every single case of disease prevented or mitigated is so much gained and may be the cause of preventing thousands of other cases. As every little loophole which is barred against the entrance of an enemy strengthens the citadel, so does the stoppage of every single channel by which disease may enter or be propagated strengthen the structure of public health.

Public health is one of the most serious concerns of the State. Bad sanitary conditions lessen the working power of an individual by constantly lowering his strength and energy, by causing periods of sickness when he cannot work at all, and by shortening his life. It is a fact which hardly needs demonstration that, other things being equal, a healthy long-lived community has enormous advantages over an unhealthy short-lived one, inasmuch as it possesses a larger proportion of working adults. This alone would ensure its supremacy in any commercial or military struggle. But furthermore its incapacity from sickness must also be much less, and its people must be more vigorous at all times. It is, therefore, apparent that good sanitation is an important element of national prosperity, and that, on economical grounds alone, it is to the advantage of communities and governments as well as of individuals to do all in their power to promote it. Indeed, the economical value and national importance of State medicine can hardly be overestimated. In the words of the President* of the International Congress of Hygiene at Vienna in 1887,—"Man is the most precious capital of the State and of society in general; every individual life represents a certain value."

---

* The Crown Prince Rudolf of Austria.

The duty of the State and of the influential and wealthy classes to initiate and promote sanitary improvements being acknowledged, an important consideration yet remains: one of the most essential factors in the sanitary progress of a community is the co-operation of the people themselves. The efforts of Government and of enlightened local authorities are often rendered more or less abortive by the passive resistance of the mass of the population. This resistance cannot usually be regarded as culpable; it is but the natural outcome of ignorance—more often a misfortune than a fault—and it is the first duty of every medical and sanitary officer, from highest to lowest, of every member of a municipality or local board, and of every other person who possesses the requisite knowledge, to assist in dispelling the darkness of ignorance which degrades the people and renders them a constant prey to misery and disease. Local illustrations are most apt to impress uncultivated minds; for instance local outbreaks or single cases of a disease, in which it can be shown that the incidence of the disease is dependent upon some form of sanitary negligence, are certain to impress them more than facts which are not obvious before their very eyes.

Combined action and public legislation are not only requisite for the execution of large sanitary undertakings, but they are equally necessary to protect individuals and communities from disease in the daily affairs of life. It is the interest of every individual not only himself to obey sanitary precepts, but to see that his neighbours do likewise. A single individual may, by his own wise conduct, ward off much disease and misery from himself; but he cannot live apart from his fellows, and he is very apt to suffer disease, and perhaps death, entirely owing to their sanitary sins. They may poison his air, his water, and his food, or sow broadcast the germs of communicable diseases: he is forced to share the results of their folly. Similarly the insanitary acts of one individual may affect a whole community; therefore, every individual who commits a sanitary offence is a public criminal of the worst kind, for his hand is against every man. Hence the necessity of punitive sanitary law.

Besides those objections to sanitary improvement which are the result of ignorance, indolence, or fatalism, one other deserves special notice, because it is the only objection of a scientific nature which has ever been advanced. A partial application of Darwinian principles has led to the conclusion * that sanitation interferes with natural law, and that degradation of the human race must be the result of a suspension or abrogation of disease as a cause of natural selection and the survival of the fittest. It may be pointed out that this objection would apply to curative more aptly than to preventive medicine. Its confutation, however, must rest upon evolutionary principles. The fact is certain that insanitary conditions affect not only the weakly, whom they kill, but the strong, whom they debilitate, and, in this way, they tend to produce a depraved race; whereas improvement in sanitary conditions, according to the doctrines of the influence of environment and improvement under improving conditions, must tend to improve the race. It might be conducive to improvement—unless the race were totally wiped out by the process—if individuals attacked by diseases which permanently enfeebled them were all to die, and thus be prevented from propagating a feeble offspring; but it is a fact that, for each one who dies, a considerable number recover with more or less damaged constitutions; such diseases being unchecked must, therefore, necessarily tend to cause degeneration of the race. On the other hand, the aim and effect of sanitation is to prevent the enfeeblement of individuals by disease, and not only to act thus, in a negative way, by preventing deterioration of the race, but also to act positively towards the improvement of the race by improving their surroundings and their mode of life. Practical illustrations of the truth of these doctrines may be observed everywhere. Persons and communities who live under the best sanitary conditions are notoriously the most vigorous; those who live in the country are more vigorous than others of the same race who live in towns under inferior sanitary conditions; those who live on high lands, where the soil is comparatively dry and the air and water pure, are more vigorous than those who live on ill-drained low lands; the unhealthy life conditions of the inhabitants of malarious tracts in South Canara and the Wynaad have produced a puny, stunted, short-lived and degenerate race, who compare unfavorably in every way with the inhabitants

---

* A conclusion which has partly been supported by the great authority of Herbert Spencer.

of healthier localities in the neighbourhood. Drainage and improved ventilation have enormously reduced the prevalence of phthisis in many parts of England to the obvious benefit of the race. From these and innumerable other examples of the kind the conclusion is inevitable that the aim of the sanitary evolutionist should be not to deprave the race by adapting it to unhealthy surroundings, but to elevate it by improving its surroundings.

The intimate nature and mode of propagation of diseases have been matters of more or less fanciful conjecture to the ancients and were very imperfectly understood until quite recently. It will be necessary to give in this place only a very brief and general account of them. The following simple classification of diseases is convenient from a sanitary point of view, with regard to their origin, propagation, and prevention:—(1) physiological diseases; (2) microbic diseases; (3) parasitic diseases.*

1. *Physiological Diseases* are those which are due to alterations of function or of structure, the result of causes other than microphytes or parasites. Diarrhœa due to congestion resulting from external cold or from the irritation produced by indigestible food is an example. The most important causes of these diseases are hereditary weaknesses or tendencies, faults in diet, exercise, or clothing, climatic influences, and chemical poisons.

2. *Microbic*, including both microphytic and microzootic, diseases are due to extremely minute parasites, visible only with the high powers of a microscope, which are called germs or microbes or micro-organisms.

These microbes belong to the lowest grade of living organisms, but they have many qualities in common with the higher plants. They may multiply in two ways—(1) by dividing into two, each half becoming a separate structure, or (2) by spores. These organisms are so very small that they can only be seen by the aid of a powerful microscope. The bacillus of anthrax is one of the largest and best known; it has the shape of a minute rod; 1,250 of these rods, placed end to end, would measure only one inch, and it would require no less than 18,000 of them, placed side by side, to measure an inch. The spores of such organisms are most inconceivably small and are contained in the air and water everywhere, ready, like the seeds of larger plants, to grow when placed in favourable conditions. These spores are much more permanent and difficult to destroy than the organisms themselves. Most microphytes are not causes of disease and will not grow in the living body. Those which do grow in the body and so cause disease may often also grow out of the body, or be cultivated artificially in the laboratory. Microphytes multiply very rapidly under favourable circumstances, and vegetables of this nature are the causes of fermentation and of decomposition by growing in the fermenting or decomposing substance. For example, if we take some fresh toddy, and, after boiling it to destroy any germs it may accidentally contain, seal it up in a perfectly clean glass bottle, it will remain clear and unchanged for any length of time. Now if we open the bottle and so admit outside air (which is full of floating germs) into it, the toddy soon ferments, froths up, and becomes turbid; it also loses its sweetness and becomes intoxicating. What occurs is this. Certain germs, which readily multiply in liquids containing sugar, having entered with the air, grow rapidly in the toddy; during their growth they decompose the sugar of the toddy into carbonic acid gas (which causes the frothing) and alcohol or spirit, which remains in the liquid. The turbidity which occurs is due to the presence of innumerable little cells, which may be easily seen under the microscope and are the microbes which cause this kind of fermentation. Similarly fruit, or vegetables, or meat are often preserved for food in tin pots from which air (containing germs) is excluded. But if the pots be opened and the contents be exposed to the air, they become infected by floating germs, and decomposition soon sets in. If a particle of any decomposing substance be examined under a powerful microscope, myriads of microbes may be seen growing in it. It is thus that the specific microbes, which cause various diseases, grow in the blood or tissues of the body and produce disease either by forming poisons (as the alcohol was formed in the toddy) or by destroying the tissues which they grow upon.

---

* Although these headings are not unobjectionable in a scientific and etymological sense, they have been adopted as on the whole expressive and convenient. Billings' classification most nearly resembles this, but he adds a class of Hereditary diseases.

Infectious, contagious, and specific diseases generally belong to this class. Each of these diseases has its own specific germ or microbe; and, to prevent the spread of the disease, the efforts of the sanitarian must be directed to destroy its seeds, or, at all events, to prevent their dissemination. Such disease germs may enter into the body in the air which is breathed, the water or food which is swallowed, and rarely through the skin.

3. *Parasitic Diseases* are due to animal parasites. These may be of large size, such as common intestinal round worms, very small, such as intestinal thread worms, or so minute that they cannot be seen without the assistance of a microscope, such as the itch insect and the blood worms. Some parasites live on or in the skin. Internal parasites may enter the body by their eggs or immature forms being swallowed with water or food, and in some cases possibly through the skin.

Having now acquired some ideas of the nature of disease, we shall, in the following chapters, consider in detail the circumstances which affect the preservation of health.

CHAPTER II.

FOOD AND DIET.

Physiology of Food.

The uses of food are: firstly, to supply material for building up the tissues of the body in early life, and for repairing them and making good their waste (which may be compared to the wear and tear of machinery) throughout the whole course of life; and, secondly, to supply fuel for warming the body and for its internal and external work.

For the repair of the tissues a comparatively small quantity of food is required. The substances of which the body is composed may be divided into three chemical groups: (1) *inorganic*, or mineral, including water, which is a constituent of all the solid tissues as well as of the fluids, the earthy salts of which the bones are mainly composed, and the more soluble salts which are contained in the fluids of the body; (2) *nitrogenous*, comprising all the active vital tissues, and remarkable for the presence of nitrogen in the composition of all the substances contained in it; and (3) *fatty*—a certain amount of fat or oil being contained in most of the tissues, and masses or layers of fat serving to pad and protect internal organs, to lessen the friction of muscles, to form a warm covering, like a blanket, under the skin, and to serve as a store of energy which may be drawn upon and consumed when food is deficient. Each of these groups must be represented in the food which is needed for the repairs of tissue. Fresh meat is such a food, and the seeds of leguminous plants, as dhal, supply largely the requisite materials. Fat may be formed in the body from the nitrogenous and other constituents of food; but only a small quantity is thus formed in the human body: most of the fat has to be supplied in food. A comparatively large quantity of food is required to be slowly burnt in the system and thus to supply energy for the action of the heart and the muscles of breathing and of the intestinal tract, nervous power, animal heat, and other internal work, as well as for the external muscular work of the body. Carbonaceous food (containing carbon united with hydrogen and oxygen) is employed for this purpose; but nitrogenous food (containing carbon, hydrogen, oxygen and nitrogen) may also be used as fuel. Oxygen is taken by the lungs from the air and carried in the blood to all parts of the body. It serves to produce energy by oxidizing (uniting chemically with) the elements of food materials, a process exactly simlar to, but slower than, the ordinary combustion of fuel in the air.

Waste materials are removed from the body (1) by the lungs—the burnt-up carbon of fuel-food passing out in the breath, combined with oxygen, in the form of carbonic acid gas, and the hydrogen, also combined with oxygen, as watery vapour; (2) by the kidneys—waste nitrogenous substances, salts, and water passing out in the urine; (3) to a small extent by the skin, which supplements the action of the kidneys and lungs; and (4) undigested portions of the food are evacuated by the bowels.

CONSTITUENTS OF FOOD.

The chemical constituents of food substances have now to be described with special regard to their use for the nutrition and repair of the tissues and as fuel for the production of animal energy.

The substances used for food may be classified thus:—

Organic	Nitrogenous.	Proteids (albumin, globulin, etc.). Albumenoids (mucin, gelatin, etc.).
	Non-nitrogenous.	Carbohydrates (sugars, starches, etc.). Hydrocarbons (fats and oils). Vegetable acids.
Inorganic		Mineral salts and water.
Food accessories		Condiments. Flavouring substances. Tea, coffee and other beverages.

Water is an essential constituent of all food and, taken partly in solid food and partly as drink, should form at least four-fifths of the total weight consumed. Milk, which is the natural food of infants, contains 88 per cent. of water. Most raw food grains contain one-eighth their weight of water, and, when boiled, more than half. Water forms about three-fourths of the weight of lean meat; and succulent vegetables contain much more; melons, for instance, 90 to 95 per cent. The use of water is to soften and dissolve the solid constituents of food, so that they can be digested and absorbed.

Mineral ingredients, or salts, are contained in all foods, and constitute the whitish ash which remains when a food substance is burnt. Rice is the only important food in which they are very deficient. Calcium and potassium phosphates, salts of organic acids, and traces of iron salts are the most important salts contained in food. Common salt (sodium chloride) is also essential, and, being contained in only small proportion in most foods, has to be added separately. Some of these salts are necessary constituents of the fluids of the body and assist in the processes of digestion and in the formation of bony and nervous tissues. The salts and acids contained in fresh vegetables and fruits are useful in preventing scurvy. About half the quantity of mineral matter required is contained in the food substances, the other half being added in the form of common salt.

Proteids and *albumenoids*, also termed *nitrogenous* or *flesh-forming* substances, are the most important and the most apt to be deficient of the solid constituents of food. They are contained in very different proportions in various articles of food, and are most abundant in animal foods and in the seeds of leguminous plants. Proteids are not only indispensable for the nutrition and repair of the tissues, but they may also take the place of carbonaceous foods (oil and starchy constituents) and serve as fuel for the production of energy.

Oils, or fats, consist of carbon and hydrogen with very little oxygen. A moderate quantity of oil in food, though not essential to life, is very conducive to health and proper nutrition. Most articles of food contain a little oil, but it is usually necessary to add more. Animal are more readily digested than vegetable oils. Oil is a most valuable source of energy, being nearly two-and-a-half times as powerful as starch.

Starchy constituents, including sugar and some other substances, are sometimes termed *carbohydrates*, because they contain, united with carbon, such a proportion of hydrogen and oxygen as together would form water. *Starch* is the principal carbonaceous food of mankind. The staple grains, which form the great bulk of human food, are composed principally of starch; arrowroot and sago consist entirely of it; and some other vegetable foods contain considerable quantities of it. Starch exists in plants in minute granules, which can only be seen by the aid of a microscope, and which differ in size and shape in each plant. To render starch easily digestible and fit for food these granules have to be burst by cooking. By strong heating, as in parching grain, starch is converted into *dextrin* which is more soluble and easily digested. *Sugar* has nearly the same value as starch as a source of energy. *Cellulose*, of which the fibres and cell-walls of plants consist, belongs to this group of substances. More or less of it is taken with all vegetable foods; but it is indigestible and passes away through the bowels.

Condiments or flavouring constituents.—Besides the essential constituents of diet, various substances are employed to give flavour and variety to food, to stimulate the digestive organs, and to act as antiscorbutics. These commonly consist of seeds, fruits, leaves, or other vegetable product containing essential oils, or of acid substances, as tamarinds, limes, vinegar.

A knowledge of the part taken by the element nitrogen which forms about 79 per cent. of the gases of the air is of value in understanding the subject of food and diet. Nitrogen is an essential constituent of living matter; it is present in every animal tissue and fluid and in all the living parts of plants. Without it there can be no life, and, unless it is supplied in adequate quantities and in a form in which it can be assimilated, both animals and plants cease to exist. The great source of nitrogen is the air of which it is the chief constituent, but, with the exception mentioned later on, it can be abstracted from the air by neither animal nor plant. Both animals and plants respire, but though they utilise the oxygen of the inspired air, they cannot utilise the nitrogen. Animals obtain the nitrogen they require by digesting the complex albuminous substances eaten as food, both animal and vegetable, but they cannot utilise the nitrogen found in simple mineral salts. Plants on the other hand obtain their nitrogen by absorbing from the soil through their roots simple mineral salts containing nitrogen, and they cannot utilise the nitrogen contained in complex organic albuminous substances. Hence crops rapidly exhaust the soil, and manuring the land, *i.e.*, supplying it with a fresh stock of plant food, becomes a necessity. This manure is either artificial or natural, the artificial consisting of simple mineral salts which can be readily utilised by plants, and the natural of waste organic nitrogenous matter which becomes disintegrated in the soil and its complex albuminous substances split up into simple salts. The process of disintegration is carried out by the agency of the nitrifying micro-organisms of the soil to which we shall again have occasion to refer when we come to the discussion of the disposal of refuse. Thus we see that dead animal and vegetable matter is rendered fit food for plants by the action of these soil organisms, and the plants in their turn form food for animals, and the waste of animals goes to recuperate the soil, and thus the cycle of life goes on.

A few years ago it was found that a certain class of plants, the *leguminosæ*, which includes the peas, beans, and such like seeds, was able to grow on a soil which had been exhausted of its nitrogen by other crops. Investigation proved that a micro-organism living symbiotically in nodules on the roots had the power of fixing the nitrogen of the air and enabling the plant to absorb it. So here we have the only natural process known by which the inexhaustible store of atmospheric nitrogen can be rendered available for entering into either animal or vegetable life.

Requirements of Diet.

Proportions of Alimentary Constituents.

Diet requisites vary to some extent with circumstances which will be mentioned further on. To understand the principles of diet we must, firstly, consider the relative quantities or proportions of food constituents, and, secondly, the absolute quantities which are required. We have seen that the main functions of food are to supply (1) nourishment and (2) energy. Thus considered the important food-constituents may be divided into two groups: (1) nitrogenous substances or flesh-formers (proteids) and (2) carbonaceous substances (oily and starchy constituents). In estimating the value of a food, it is convenient to consider all the carbonaceous constituents as if they consisted of starch only. For this purpose the weight of oil should be multiplied by 2·4, to get its equivalent of starch, and this should be added to the weight of the starchy constituents. Thus the *proportion* between the nitrogenous and carbonaceous ingredients may be easily observed. In a good diet the ratio should not be less than 1 : 6 ; that is, *for every six parts of carbonaceous there should be at least one part of nitrogenous material.* This rule is founded upon practical experience as well as upon physiological considerations.

A second general rule, though one of less importance than the first, based on similar grounds is, that *at least a similar proportion* (1 : 6) *should exist between the oil* (reckoned as starch) *and the total carbonaceous constituents* reckoned as starch.

To state the matter in the usual way, the following figures show the smallest relative quantities of nitrogenous and oily to starchy constituents which may be contained in a good diet.*

Nitrogenous ..	3	Oily	1
Starchy	15		

While smaller proportions than these of nitrogenous and oily substances should not be contained in a good diet, there are certain circumstances under which the proportions of these alimentary constituents may be increased with benefit. Such circumstances are youth, habit, climate, work, disease.

Youth.—A large proportion of nitrogenous and oily constituents are required in the diet of the young and growing to afford material for building up the tissues of the body. Human milk, which is the natural diet of infancy, contains nitrogenous and carbonaceous constituents in the proportion 1 : 3·5 and nearly half the weight of the carbonaceous constituent is oil. As age advances these proportions

---

* The approximate composition of the different classes of foods is :—

——	Nitrogen.	Carbon.	Hydrogen.	Sulphur.
	PER CENT.	PER CENT.	PER CENT.	PER CENT.
Proteid	16	50	1·8	1·4
Fat	...	75	11	...
Carbohydrate ...	...	40–45	...	...

may be gradually reduced, especially as regards oil ; but it should not be forgotten that, until growth is complete, the diet of young persons ought to contain a larger proportion of nitrogenous and oily constituents than that of adults. A frequent error in feeding children is to give them too large a proportion of starchy food, and thus, though their stomachs may be over-distended with an excessive quantity of food, they are ill-nourished and unhealthy. Children also need a sufficient supply of lime salts in their food to afford material for the formation of their bones and prevent the occurrence of rickets.

Habit may cause life to be supported wholly upon nitrogenous and oily foods, to the exclusion of starchy materials. The inhabitants of cold and wild regions, where animal flesh and fat are almost the only food obtainable, afford instances of this habit. Persons unaccustomed to the use of starchy food do not easily digest it ; and those whose staple food is starch may find it difficult to digest sufficient quantities of oily and nitrogenous materials to supply its place. Therefore great and sudden changes in the habitual proportions of food constituents are to be deprecated.

Climate.—It is obvious that the portion of the food which is required to maintain animal heat by its slow combustion in the body need be much less in hot than in cold climates and in hot than in cold weather. Hence a large proportion of oily food is particularly useful in cold climates, as it supplies the necessary fuel in a less bulky and more readily digestible form than its equivalent of starch.

Work.—When unusually hard work has to be done an addition of oily food, or the substitution of oil for some of the starchy constituents of diet, is very useful for the same reason as that above stated. A proportionate increase of nitrogenous food is necessary at the same time, because carbonaceous food cannot be properly digested without such an admixture.

Disease.—The proportion of alimentary constituents in diet is often of great importance in the treatment of disease ; but a consideration of this subject belongs properly to the physician and cannot be discussed here.

Diets may be faulty by relative excess or deficiency of certain constituents. A common fault in the diets of both rich and poor in India is a deficient proportion of nitrogenous matter. The consequence is that, to supply a sufficient quantity of this for the ordinary nutrition of the body, a large excess of carbonaceous matter is habitually consumed. The effect of such a diet is to produce improper nutrition of the vital tissues, with an undue deposit of fat, frequent indigestion, and sometimes fatty degeneration of organs or diabetes. For instance, rice contains only 1 part of nitrogenous to 11 of carbonaceous material ; and, as the lowest proportion for a good diet is 1 : 6, it follows that, in a diet consisting exclusively of rice, if only a bare sufficiency of nitrogenous aliment is taken, nearly double the necessary quantity of carbonaceous material must be swallowed at the same time. In other words, two pounds of rice have to be taken to do, in an imperfect manner, the work of one pound of a correctly constituted food. It is obvious too that the intestines are unduly burdened by having to contain this mass of vegetable matter, and that the individual is wasting energy by carrying about from day to day a weight of material inside him much of which consists of waste and indigestible matter.

We have seen that nitrogenous may take the place of carbonaceous constituents in diet ; therefore relative excess of digestible nitrogenous food is not likely to be hurtful, unless the total quantity of food be too large.

Excess of certain salts may occasionally be injurious, as when excess of lime salts induces stone in the bladder. On the other hand, deficiency of such salts may lead to rickets in children, and to defective nutrition of nervous and other tissues. Deficiency of common salt may cause indigestion and encourage the breeding of intestinal parasites.

A due proportion of oil is not so essential as a sufficient proportion of nitrogenous material in food, because some oil can be formed in the body from other constituents of food. Only a limited quantity, however can thus be formed in the human body, and a certain proportion of oil is therefore required in every good dietary. An excess of oil, particularly if it be vegetable, and if the total amount of food be in excess, is apt to produce dyspepsia and diarrhœa in persons not accustomed to it ; but, if taken habitually, it is likely to cause obesity. Oil is particularly required as an adjunct to food consisting of starchy and albuminous substances which are deficient in it.

Quantity of Food required.

The daily quantity of dry food materials required by an adult, during idleness, is about 0·15 oz. for each 1 lb. weight of the body, or in other words, $\frac{1}{105}$ of the body weight. A man weighing 105 lbs. and doing no active work will therefore require 1 lb. of dry food constituents daily. At least 2 oz. of this should be nitrogenous material, $\frac{3}{4}$ oz. of oil (which is equivalent to 1·8 of starch), and ·7 oz. salts. The daily quantities in a subsistence diet for an idle man weighing 105 lbs. would thus be in ounces:—

Nitrogenous ..	2	Oily	$\frac{3}{4}$
Starchy	$11\frac{1}{2}$	Salts	$\frac{3}{4}$

If oily constituent cannot be given, the quantity of starch should be increased to $13\frac{1}{4}$ oz.*

These quantities must be increased or diminished in proportion to body weight. There are other circumstances besides the weight of the body which may modify, more or less largely, the quantity of food which is required. These are youth, work, habit, climate.

Quantity of food in relation to age.—During growth much more food is required, in proportion to weight of body, than in adult life. It has been already mentioned that this food should also be more nitrogenous and oily. The total daily quantity of dry food constituents needed by an infant may be stated as 0·6 oz. for every 1 lb. of body weight or about $\frac{1}{26}$ of total weight. At 10 years of age the quantity will be about 0·3 oz. per 1 lb., or $\frac{1}{50}$ of total; and after puberty, about 0·202 per lb. or $\frac{1}{80}$ of total weight until growth is complete.† For subsistence a man requires 0·1 oz. of water

---

*

Dry, *i.e.*, water free.	Rest.	Ordinary work.	Hard work.
	oz.	oz.	oz.
Proteids	2·5	4·5	6·5
Fats	1·0	3·9	5·0
Carbohydrates	12·0	14·0	16·0
Salts	0·5	1·0	1·5

† These deductions are made from Letheby's figures.

14·6

free food for each pound of body weight and for ordinary work about 0·7 oz.

Quantity of food in relation to work.—The relation between food and work is of the highest importance. It is a matter of daily experience that increased work requires increased food. Men, like other animals, lose weight by consuming the tissues of their own bodies, if their food does not bear a sufficient proportion to the work which they do, until ultimately they succumb to disease or become unable to accomplish so much work. As fuel, in a steam-engine, may, by its combustion, supply mechanical energy, so may food, in the animal body, by a chemically similar, though slower, combustion, supply mechanical energy; and the animal body is a more perfect machine than the steam engine: for while in the latter only $\frac{1}{10}$ of the theoretical energy of the fuel can be utilized as mechanical work, fully $\frac{1}{5}$ of the energy of man's food can be realized.*

The amount of energy that can be obtained from a given weight of matter is proportional to the amount of heat given out during its combustion. This heat is measured by the standard unit called the "caloric" and is the quantity required to raise the temperature of 1 lb. of water 1° Fahrenheit. Converted into mechanical energy a caloric is equivalent to the work done in raising 772 lbs. 1 foot high, or, as it is generally called, 772 foot-pounds of work. When using large numbers it is found convenient to convert the pounds into tons, and the work done in raising 1 ton 1 foot high is spoken of as one foot-ton.

Just as a given weight of coal or wood, when completely burnt up, gives out a definite quantity of heat which can be measured and stated as mechanical energy, so do given weights of food stuffs, when entirely consumed, give off definite quantities of heat which can be expressed as mechanical energy. The value of food stuffs as power producers corresponds, therefore, with their value as heat producers, and now that the heat equivalents of most food materials have been worked out and tabulated it is possible to get a fair idea of their respective nutritive values. Such tables cannot be taken, however, as showing the exact value of the different substances from the point of view of nutrition, since the digestibility and assimilability of the foods in the body have to be taken into account; still they form a uniform basis for comparison.

---

* Helmholtz.

The internal work performed in the body during 24 hours has been calculated to amount roughly to—

242	foot-tons	for maintaining	the circulation.
39	do.	do.	respiration.
2,519	do.	do.	the bodily temperature.
2,800			

This quantity of energy must be supplied by the food if mere existence is to continue, and external work is not provided for at all. 300 foot-tons is reckoned to be a fair day's work for an average man. In order to perform this, since $\frac{4}{5}$ of the energy expended in doing work is lost as heat, 5 times that amount of energy is required to be available. So that the amount of energy that must be supplied by the food daily is—

	2,800	foot-tons	for internal work.
(5 × 300)	1,500	do.	for external work.
Total ...	4,300		

150 foot-tons a day is a light day's work, and is about the amount done by a man who does the ordinary business of life without manual labour. 600 foot-tons is a very hard day's work which cannot be maintained for many days in succession by ordinary people. To give an idea of what this means it may be stated that a man walking at the rate of 3 miles an hour along the level does work equivalent to raising $\frac{1}{20}$ part of the weight of his body through the distance walked. If he carries a weight this has to be allowed for, and if he ascends a hill the height has to enter into the calculation. Assuming that a man weighs 120 lbs., in walking one mile under the above conditions he does work equivalent to lifting 14 tons 1 foot high, and in walking 20 miles 280 foot-tons. If at the same time he carries a weight of 40 lbs., he does 18 plus 280 foot-tons of work.

In a standard diet the proportions of food stuffs are:—

Proteids ..	100	Carbohydrates ..	315
Fats	65	Salts	23

and the energy derivable is about 4,000 foot-tons.

Proteids 2½ ℥
fats 1 ℥
Carboh 12 ℥
Salts ½ ℥
16 ℥

The mechanical value of the different classes of food may be reckoned as follows :—

1 oz. dry albuminate (proteid) yields about 173 foot-tons of potential energy.
1 oz. dry fat yields about 378 foot-tons of potential energy.
1 oz. dry carbohydrate yields about 135 foot-tons of potential energy.

so we see that the fats stands highest in the scale as a source of energy. In order, however, that nutrition may be properly carried on it is necessary that the different classes of food be eaten in due proportions as indicated above in the standard diet. From these data the additional amount of food required for any additional amount of work may be easily calculated, always remembering that five times the theoretical amount of food must be taken as only one-fifth of its potential energy is actually realizable.

Two foot-tons for each pound weight of the body is a fair day's work for a man, 3 foot-tons per pound is hard labour. From the data given above, it may be calculated that for 200 foot-tons of work a man may properly receive the following addition to his subsistence diet :—

	oz.		oz.
Proteids	1	Oil	½
Starch	5		

Habit.—Most people who can afford it eat considerably more food than they require and assimilate only the more easily digestible portions of their food. If the food of such overfed persons be suddenly diminished to about their actual needs, they will be partially starved at first, owing to their being unable to digest all the nutriment of their food. Again, grain eaters, who are accustomed to distend their stomachs with large quantities of food, containing far too much starch, though perhaps not a sufficiency of proteids, will at first suffer from hunger if their diet be changed for a less bulky, although more nutritious one.

Climate.—In cold climates, as already mentioned, more food is required than in warm climates because more is needed to maintain the heat of the body, supposing the amount of work done to be the same.

The effects of deficiency of food, if sudden and complete, are hunger, followed by great weakness, and wasting of the fat and other tissues of the body. Under favourable circumstances a person may live for about three weeks without food, but death generally occurs in less than half that time. Exhaustion supervenes very rapidly if hard work be done without food. In the author's experience a case occurred where a working party of sepoys, marching through a mountainous country, had to perform very hard labour for many hours, without being able to obtain food. Several of them fell into a state of collapse, resembling that of cholera; but they were speedily restored by suitable warm nutriment and rest. Partial and continuous deficiency of food will be considered in the appendix on famine.

Excess of food is habitually taken by many people without any very obvious ill effects, the unused excess passing away by the bowels. Great excess, however, leads to an unhealthy plethoric condition, with digestive troubles, and a tendency to structural degeneration or other diseases of various organs, for instance, of the liver or the kidneys.

FOOD MATERIALS.

Hitherto we have been considering the more theoretical aspect of food and diet: we have now to see how the scientific principles of diet are to be practically applied.

Natural food substances may be classified thus:—

1. Staple food-grains.
2. Leguminous grains.
3. Animal foods.
4. Oils and fats.
5. Starches and sugars.
6. Vegetables and fruits.
7. Condiments.

In the following paragraphs some account is given of the principal substances contained in each of the above classes:—

Staple food-grains.

Grain of some kind forms the principal article of food everywhere in India. The staple grains nearly all belong to the order of grasses (N.O., *Gramineæ*), often termed cereal grains. The staple grain of each place is that which is most largely cultivated and cheapest in the locality. Thus, in Southern India, rice is extensively cultivated and forms the staple food of large populations in the coast districts, along the course of the large rivers, and wherever else there is an abundant supply of water for irrigation; ragi forms the staple in many places where the soil is moist, but not sufficiently so for rice; while, on drier lands, some other kind of millet, such as cholam or kambu, forms the staple food. The cereal grains, which may fitly be called "primary foods"[*] form the great bulk of the food of people of all religions and castes, rice being usually preferred by Brahmins and the wealthier classes.

It is mainly in the choice of secondary foods that religious and caste influences are noticeable.

These grains contain too small a proportion of proteids and of oil to form perfect foods, and they consequently require the addition of other food stuffs which are rich in proteids and oil. Rice is particularly deficient in both respects, as well as in the proportion of mineral matter which it contains. Wheat contains a sufficiency of proteids and mineral matter, but not sufficient oil. The millets, which include most other cereal food-grains, are inferior to wheat in the proportion of proteids which they contain, but superior to it in the proportion of oil. In India the millets, taken all together, are more important than either rice or wheat because they form the staple food of larger populations. The ash (mineral residue) of cereal grains consists largely of phosphoric acid and potash, which are two of the most valuable mineral ingredients of food. The following table shows the percentage composition of the principal staple food-grains of India [†]:—

Grain (husked).	Proteid.	Starch.	Oil.	Ash.	Water.	Fibre.
Rice	6·5	79·1	0·6	0·6	12·8	0·4
Koda	7·0	77·2	2·1	1·3	11·7	0·7
Ragi	7·3	73·2	1·5	2·3	13·2	2·5
Gundli	9·1	69·0	3·6	3·5	10·2	4·6
Maize (Big joar or cholam)	9·5	70·7	3·6	1·7	12·5	2·0
Great millet (small joar or cholam)	9·3	72·3	2·0	1·7	12·5	2·2
Bajra (kambu)	10·4	71·5	3·3	2·0	11·3	1·5
Italian millet (kangu, tenai)	10·8	73·4	2·9	1·2	10·2	1·5
Varagu	12·6	69·4	3·6	1·4	12·0	1·0
Wheat	13·5	68·4	1·2	1·7	12·5	2·7
Amaranth	13·7	58·4	6·0	5·2	11·9	4·8

---

[*] Cornish on Food and Prison Dietaries, 1864.

[†] This table is taken from Church's *Food-Grains of India*, 1886 (from analyses by Forbes Watson and Church), but the author's figure for albumenoids in rice has been substituted as more nearly representing the average composition of that grain. In recent analyses made by the author of good samples of several food-grains obtained in Madras the proportions of albumenoid were almost identical with those here given, except in the case of cholam, in which they were considerably, and in ragi, in which they are slightly, higher.

In the preparation of these grains for food, husking or removal of the outer coverings of the seeds is the first operation. This is commonly accomplished by beating the dry grain with a pestle and winnowing away the husk.

The method of cooking varies with different grains and in different places, but there are four principal recognised methods: (1) the grain is boiled whole in a considerable quantity of water, which is strained off as soon as the grain is sufficiently cooked: it swells by absorbing water and about doubles in weight; the cunjee water is drank separately, fresh, or after it has become acid by fermentation on keeping; (2) the grain is pounded or ground in a hand-mill, and the meal or flour thus obtained (or sometimes the whole grain) is boiled with a moderate quantity of water, so as to form porridge, or with less water to form pudding; (3) the meal or flour is made into a thick paste with water and formed into cakes, which are baked on a pan; (4) the grain is parched by stirring it in hot sand and sifting it out. A mixture is often made of cholam, ragi, varagu or other grains, or of ragi or millets with rice, especially for cooking in the form of porridge or pudding. In whatever way the grain be cooked it is eaten either hot or cold along with salt and various condiments and with or without ghi or oil, dhal, meat, vegetables, sugar or other subsidiary articles of food.

Attention may here be usefully directed to a few practical points connected with these staple grains.

Rice is eaten by about one-fourth of the population in Southern India.* Eight parts of husked rice yield five of cleaned rice, and two parts of the latter, when boiled, yield five parts.† Rice should be kept for at least six months after it is harvested, because new rice is unwholesome, and apt to cause indigestion and diarrhœa. Partly boiled paddy keeps better and is probably more wholesome, though less white in color, than raw table rice. New rice can be cooked in about half an hour, yields a thick cunjee water, and does not keep well after cooking. Old rice takes about twice as long to cook, yields a thin cunjee water, and keeps good for more than 24 hours after cooking.‡ Rice owes its popularity as an article of diet to the digestibility of its starch grain. It should be cooked by steaming and not by boiling, as most of its proteids and salt are dissolved out by the water. If the cunjee too is used this does not so much matter. It forms a suitable habitual food if its deficiencies are made good by the addition of substances containing proteid and fat. Dhal or some other leguminous seed or animal food will supply the former, and milk, ghi and vegetable oils the latter.

---

* More than 30 per cent. of the population of the Madras Presidency according to the Famine Commission.

† Church.

‡ Dr. Short quoted by Cornish.

Ragi is superior to rice in the proportion of proteid, oil, and especially of mineral matter, which it contains. In its proportion of proteid and oil it holds a position intermediate between rice and the other millets. If combined with a sufficiency of proteids and oily substances it forms an excellent staple food. It is, however, apt to disagree at first with persons unaccustomed to its use, and, as a rule, it is eaten only by the labouring classes. In parts of Mysore, Hyderabad, and many Madras districts it is much used. Ragi possesses the advantage of keeping good for an indefinite period, and it has been found perfectly preserved in grain pots which have been disinterred after having lain buried for more than a generation. Ragi is commonly eaten as porridge or pudding; but it is sometimes cooked in the following way. The ground grain is mixed with cold water and exposed to the sun for a day or two, until it becomes sour, when it is boiled and allowed to cool. It then forms a jelly with a pleasant acid flavour.

The other millets mentioned in the foregoing table are koda, gundli, joar (cholam), bajra (kambu), kangu, varagu. The composition of these grains varies a good deal in different samples, but (with the exception of koda, which is about equal to ragi) they may be taken as averaging about 10 per cent. of proteid, 3·5 per cent. of oil, and 71 per cent. of starch. Thus the ratio of proteid to carbonaceous constituent would be nearly 1 : 8, and of the oil to total carbonaceous as 1 : 9·5, so that a moderate addition of albuminous and oily substances is required to render the millets perfect foods. They are certainly far superior to rice and but little inferior to wheat as staple food-grains.

Wheat is an important food in parts of the Punjab, United Provinces, Central Provinces and Bombay. In Madras it is not habitually eaten except by Europeans and some wealthy Muhammadans. It contains a sufficient proportion of proteid (1 : 5·3), but is deficient in oil (1 : 25) to serve as a complete food.

Wheat is ordinarily prepared for food by being ground into flour, the flour being separated into *suji*, which is the finest and most starchy part, *maida* the medium, and *ata* the coarsest. The outer indigestible coats of the grain form the bran, which is rejected, but ata contains some of the finer inside coats and is richer in proteid, oil, and salts than suji or maida. The latter are used for making sweet-meats.

Ata is commonly made into a paste with water and fashioned into cakes (chapaties) which are baked at a moderate heat. Biscuits are wheaten cakes baked at a high temperature. Bread is a spongy form of wheaten cake, which is more easily digestible than the chapati, and is generally made by adding fermenting toddy, or yeast, to the paste (dough) formed by kneading flour and water. The bubbles of gas liberated during fermentation form little cavities in the bread and render it light and porous. 100 parts by weight of flour should yield 136 parts of good bread.

Amaranth is the only staple grain here mentioned which does not belong to the order of grasses. The plant is generally cultivated in mountainous parts of the country and its seed often forms the principal food of the inhabitants of those regions. In the Deccan these seeds are eaten on fast days by Hindus, and are usually parched and taken with sugar. The green leaves of amaranth are used as a vegetable. This grain is the most nutritious of all the staple grains here mentioned and alone contains a proper proportion of proteid and of oil.

Leguminous Grains.

Leguminous food-grains, often termed pulses, are the seeds of pod-bearing plants, such as the various kinds of dhal, gram, beans and peas, and form valuable and much used food materials. They are principally remarkable for the large proportion of proteid which they contain and for their comparative indigestibility. For the former reason they are extremely useful in supplementing the deficiency of albuminates in cereal grains; but for the latter reason they can be eaten only in very limited quantity. Dhal, especially if not well cooked, is a frequent cause of diarrhœa and is often passed undigested by the bowels. It is particularly likely to disagree with persons unaccustomed to its use.*

---

* Kasari dhal (*Lathyrus sativus*, vetchling) which is used in parts of North-Western Provinces and Oudh, when habitually eaten in large quantity causes paralysis of the legs. Some kinds of *Phaseolus*, as *Phaseolus lunatus*, also appear occasionally to have poisonous properties.

The digestibility of these grains is promoted by admixture with easily digestible foods and by careful and prolonged cooking after being soaked or ground.*

Besides being very rich in proteid, the pulses are rich in mineral matter (containing much phosphorus and sulphur), and, although they generally consist largely of starch, some of them contain much oil instead of starch.

The quantity of pulse consumed daily by non-flesh eaters is usually 2 to 4 oz., and it is not advisable that the latter quantity should be much exceeded.

The following table † gives the percentage composition of some of these grains :—

Name of pulse.	Proteid.	Starch.	Oil.	Ash.	Water.	Fibre.
Chick-pea (Bengal gram)	21·7	59·0	4·2	2·6	11·5	1·6
Mung gram ...	22·7	55·8	2·2	4·4	10·1	4·8
Pea	23·6	57·5	1·5	2·5	11·8	1·0
Lentil	24·9	59·5	1·3	2·2	11·8	1·2
Ground-nut ...	24·5	11·7	50·0	1·8	7·5	4·5
Soy bean ...	35·3	26·0	18·9	4·6	11·0	4·2

The pulses are prepared for food in various ways: (1) the grain is soaked in water until it swells (for 24 hours or less), or, even without soaking, it is husked and boiled with condiments and eaten, generally with the addition of vegetables, as a curry, along with the staple food; (2) it is ground, mixed with condiment and made into cakes or small balls, which are often fried in oil or ghi, and also eaten with staple food; (3) it is parched, in the same way as rice and other grains, and thus is often used as food by labourers and travellers.

The green pods and young leaves of many leguminous plants are valuable and largely used as vegetables.

The number of leguminous grains which are used as food is considerable, and the above table gives analyses of only a few typical examples. Mung gram may be taken as an average representative of the various kinds of gram and dhal in ordinary use. Pulses rarely contain less than 20 per cent. of proteid, peas sometimes contain 28 per cent., and soy beans more than 35 per cent. A good Madras sample of Tur dhal, analysed by the author, contained over 25 per cent.

---

* Church.

† From Church's *Food-Grains*.

The ground-nut is remarkable for the large quantity of oil which it contains. It is commonly prepared as food by being roasted and husked.

The soy bean is largely used in China and is cultivated in India and Upper Burma. It is the best of all pulses for supplementing the deficiencies of rice and other starchy cereals because of its great richness in proteid, oil and mineral matter.*

Animal Foods.

Animal albuminous foods are the most easily digestible and, in most countries, the most extensively used of substances rich in albuminous material. The flesh of various animals, including fish, is eaten by Europeans, Muhammadans and the majority of Hindus when they can get it. Flesh eating Hindus are by their religion precluded from eating beef; while for the same reason, Muhammadans may not eat pork. Brahmins and other caste Hindus, who may not eat any flesh, are, however, very partial to milk, in its natural state, or in the form of curds (tyre) or butter-milk and ghi, as an article of diet, and many so-called vegetarians eat eggs. The percentage composition of the most important animal albuminous foods is shown in the following table† :—

—	Proteid.	Oil.	Sugar.	Water.	Salts.
Lean meat	18·3	4·9	...	72·0	4·8
Fish	16·0	5·0	...	78·0	1·0
Eggs	14·0	10·5	...	74·0	1·5
Milk	4·8	3·3	4·2	87·0	0·8
Blood	21·2	0·3	...	77·9	0·6

In the above analyses the meat is without bone or fat and the eggs are without shell.

---

* Church.

† Meat—lean mutton—Letheby.
Milk of Bengali cows—Macnamara.
Blood—Becquerel.

Dried fish and dried meat contain nearly 50 per cent. more proteid constituents than the same articles when fresh.

Meat is commonly prepared for food by being cut into pieces about an inch in diameter, which are (1) mixed with curry stuff and fried in fat, oil, or ghi ; (2) spitted together, smeared with condiments and fried or roasted as kabab ; (3) boiled or stewed along with vegetable curry. Europeans generally roast or boil meat in large pieces. Meat loses about 20 per cent. in weight by boiling and 30 per cent. by roasting. The proportion of bone and fat in meat varies much with the kind and condition of the animal and in different parts of the same animal. In average Indian mutton bone forms about 25 per cent. of the whole carcase and fat less than 15 per cent.

Fish is generally a wholesome and nutritious food, being nearly equal in value to lean meat. Fish, whether fresh, salted or dried, is a favourite ingredient of curries. It is deficient in mineral constituents.

Salted and dried fish, though in itself wholesome if the processes have been properly performed, is without doubt responsible for a vast amount of intestinal derangement and sometimes death among the poorer classes, since much of the salt-fish that finds its way into the hands of the consumer has been only half cured and is eaten in a state of decomposition.

Some kinds of fish* are always, and others are occasionally poisonous. *Crustacea* such as prawns, and *mollusca*, such as oysters, resemble fish in nutritive value but contain less oil.

Eggs of the common fowl, or of other birds, form a completely digestible food, which is, weight for weight nearly equal to lean meat in proteid and superior to it in oil. Eggs are often eaten hard boiled and cut up in curries ; but they are more easily digested if the white and yolk be mixed together and boiled (poached) or fried in ghi or oil to form an omelette which may be cut up and curried. Eggs differ a good deal in size; an average Indian hen-egg (deducting shell) weighs about 1¼ ounce.

---

* Intestinal irritation and collapse and sometimes delirium are caused by poisonous fish. The poisonous nature of the globe fish is well known, and the occasional poisonous effect of oysters. Dr. Day mentions a barbel and a carp found in Himalayan streams which are poisonous. The Indian mackerel (Scomber) and sardine (Clupea), both abundant on the Malabar coast, are sometimes poisonous, especially when beginning to decay. Fish may become more or less poisonous from being kept in very foul tanks.

Milk is an important food in all countries, but in India it is especially so, as it forms the sole animal food of Brahmins and some other classes and is more or less partaken of by all. The quantity of milk yielded by cows varies considerably with the breed and food of the cow and the age of her calf; Indian cows do not often yield more than 4½ pints in a day. This is about a quarter of the yield of a good English cow, and the chief reason for the small quantity and bad quality of the milk of the Indian cow is the want of proper nourishment. The cow owner expects the cow to give everything and to receive practically nothing. Admitting that fodder is sometimes scarce it is a fact that, even in times of plenty, cows in towns are habitually under-fed. The composition of cow's milk is tolerably uniform except with regard to cream (oil) which varies considerably (1·9 to 4 per cent. or more). Milk is rarely taken raw, except by Europeans; boiled milk is preferable because it keeps better and any germs which may be present are destroyed by boiling. The milk of animals for some days after calving is of a very oily nature and likely to cause diarrhœa.

Tyre is milk boiled down, some water being thus evaporated, and coagulated by the addition of an acid (which causes the casein to solidify). It may be reckoned as a little superior to ordinary milk in nutritive value.

Cream consists largely of the fat of milk together with a little proteid and sugar. On standing milk in a cool place about 60 per cent. of the fat rises to the surface and can be skimmed off. The skimmed milk which remains is still a valuable food as it contains most of the nitrogenous matter and sugar originally present in the whole milk. Of late years centrifugal machines have been largely used for mechanically separating the cream, and by this agency 90 per cent. of the fat can be readily extracted in a short time, the remaining liquid being of course much poorer than skimmed milk.

Butter.—When milk is churned or violently agitated by mechanical means the globules of oil are induced to coalesce and a solid mass of milk fat mixed with a variable quantity of milk proteid and water is obtained.

Butter milk is the liquid remaining after the removal of the butter. It resembles skim milk in composition, but contains less fat and is slightly acid.

Ghi is made by heating butter till a clear and sweet smelling residue is left, fluid at ordinary temperatures, but becoming semi-solid during colder weather. The quantity of ghi obtained is much less than that of the butter used, and it is, consequently, much more expensive; so much so that pure ghi is scarcely obtainable in large towns except to order. It is the chief source of fat in the diet of the vegetable eating Hindu.

Blood is a very valuable and easily digested food, which is often partly or wholly wasted when animals are slaughtered. It is the practice to drain off as much blood as possible from a carcase, but it ought all to be carefully saved. It may be cooked by being mixed with condiments and fried in ghi or oil, or it may be mixed with milk or with eggs or with the flour of any grain and be fried or otherwise cooked.

Oily Foods.

Oily may be divided into animal and vegetable, the former being the more readily digestible. Solid animal oils are commonly termed fats. Ghi is the most familiar example of an animal oil in this country. Fat is found in all animals on the inside of the loins and under the skin, as well as in other parts. The liver of fish contains a large amount of oil. Pork contains much more fat than any other kind of meat.

Vegetable oils are expressed from various seeds: groundnut, cocoanut, and gingelly oils, and kokam-butter, are the vegetable oils most used as food. Ghi and melted purified fat consist entirely of oil. Butter contains about 81 per cent. of oil, 4 of casein, 2·5 of salt, and 12·5 of water. Crude fat is very similar in value.

Starches and Sugars.

The principal starches are the different kinds of arrowroot, obtained from several plants, and sago, from the pith of certain palm trees. They consist of starch with about 17 per cent. of water and are almost entirely digestible. Potatoes and yams contain about 20 per cent. of starch.

Sugar of the refined and crystallized kind, produced from the juice of the sugar-cane, is used only by the wealthier classes. It contains about 5 per cent. of water. Jaggery, which is commonly used, is a less pure sugar, obtained by boiling down the juice (toddy) of some palm trees, especially the palmyra and bastard date. In Europe a great deal of sugar is now extracted from beet-root and goes by the name of beet-sugar, and in America from the sap of the sugar maple.

Vegetables and Fruits.

Vegetables and fruits are of much importance in diet, their special value depending not so much upon the amount of nutriment as upon the vegetable acids and salts which they contain and which render them necessary ingredients of a perfect diet. Persons who are deprived of vegetables or fruit, especially if they have been previously accustomed to them, suffer from a diseased condition termed scurvy. Vegetables are nearly always eaten cooked, and fruits raw, some fruits being used either as fruit or as vegetable.

Vegetables are ordinarily cooked by being (1) boiled with condiments as mulligatawny, (2) used as dry curry boiled and smeared with curry stuff, or (3) fried in ghi or oil and mixed with curry stuff as ordinary curry.

Vegetables and fruits may be divided into four classes: (1) starchy and saccharine, (2) green, (3) watery, and (4) condimentary, all classes being valuable antiscorbutics.

The starchy and saccharine vegetables are usually tuberous or fleshy roots, such as the potato, yam, carrot, onion and radish. These, and fruits of kindred nature, such as the plantain, custard apple, and bier, are of considerable value as foods. The sugar-cane, though not a fruit proper, may, for diet purposes, be classed with these fruits.

Some green vegetables are also useful as nutritives, such as the pods of many leguminous plants, brinjal, and bandakai. Cabbage and greens of various kinds are less nutritive and are useful mainly as antiscorbutics. Watery fruits and vegetables, as the various kinds of cucumber, pumpkin and melon, the jack, mango, orange and grape, are good and pleasant antiscorbutics.

Condimentary fruits and vegetables are also useful for the same reason, but are principally employed for flavoring other food. Such are tamarinds, limes, turmeric, and aromatic leaves, fruits, and seeds of various kinds as capsicum, coriander, pepper, omum, &c.

Nuts, such as cashew-nuts, almonds, and walnuts are not very common articles of food, except cocoanut which is generally used as a condiment in curries; but they are rich in proteid and in oil, and consequently very valuable as food. They are, however, apt to disagree with those unaccustomed to them and they are indigestible unless well masticated.

Fruits and vegetables, wholesome in themselves, often cause indigestion and diarrhœa, because they are eaten in excessive quantity, or are unripe or overripe or stale; but they are sometimes unwholesome owing to the possession of more or less poisonous properties, for instance wild varieties of the cucumber order.

BEVERAGES.

A consideration of foods would be incomplete without some notice of alcoholic and other liquids which are commonly used as drink. Water, the only essential beverage, is so important that it is treated of in a separate chapter. Other beverages may be classed as: (1) sherbets, (2) alkaloidal drinks, (3) fermented liquors, (4) distilled liquors.

Sherbets are made from the juices of various fruits, such as the lime, orange, grape, or pomegranate, mixed with water, and sometimes with sugar and aromatics added. They are pleasant and wholesome drinks, valuable as antiscorbutics. Cunjee-water and pepper-water may be classed with these beverages.

Tea and coffee are the principal alkaloidal drinks, so called because their active constituent is a substance belonging to the class of alkaloids. Tea also contains tannin, to which dyspepsia and constipation are occasionally due if the tea be too strong or too long infused, and coffee contains some oil. These drinks are of no value as nutrients, but they are mild non-intoxicating stimulants. Like other warm drinks their mere warmth has a certain stimulating effect. Coffee is a stimulant to the heart, but tea is said not to be. The effect of both tea and coffee is usually tonic and beneficial, but, if used to excess or in peculiarly excitable temperaments, they may be prejudicial and lead to undue nervous excitement and sleeplessness.

Fermented liquors are produced by the fermentation of sugar or starchy substances mixed with water. *Toddy* and *beer* are the most important of these liquors. Toddy is the juice of various palms, principally the palmyra, bastard date, and cocoanut. The juice as it flows from the tree consists of water, containing a considerable quantity of sugar and a little albuminous matter in solution ; but it soon begins to ferment (owing to the growth of certain microphytes in it), its sugar being converted into alcohol and carbon dioxide gas ; the latter is the cause of the frothing up of fermenting toddy. The fermentation is complete usually within 24 hours. Cocoanut toddy ferments most rapidly and contains most alcohol, date toddy comes next. Toddy averages about the same strength as rather light beer * and is very similar to it in its effects.

Beer is obtained by fermenting malted grain, usually barley or rice, or grain prepared by being strongly heated by steam. Both beer and toddy contain a small quantity of sugar and albuminous substance, which, besides their alcohol, give them some little value as food.

Distilled liquors are obtained by distilling the alcohol (mixed with water) from fermented mixtures of sugar or starchy substances. The peculiar flavors and odours of different kinds of spirit depend upon the presence of minute quantities of various essences derived from the substances used, but alcohol is the principal ingredient of all. Toddy, jaggery, the refuse of sugar factories, mhowa flowers, and grain are the principal substances from which distilled liquors are obtained in this country.†

The strength of ordinary arrack is about 40 per cent. of pure alcohol, by volume (30° under-proof).

---

* Average strength, stated as *proof spirit* per cent. (proof spirit is nearly half pure alcohol) : cocoanut toddy 11·9, date 10·3, brab 8·2. *Lyon* Rept., Chem. A., Bombay, 1883.

† Cashew-nut fruit is used on the Malabar coast, and Sorghum cane and prickly-pear fruit have been used in other places.

The effects of alcoholic liquors depend upon the degree of dilution of the spirit with water or food and upon its absolute amount, as well as upon individual peculiarities. A small quantity of alcohol only unites with oxygen in the blood, thus evolving heat or other form of energy and at the same time preventing the consumption of other carbonaceous food by depriving the blood of oxygen.* Thus only a small quantity of alcohol can be consumed in the body. A large quantity acts as a poison by causing certain injurious changes in the blood and by its effect upon the nervous centres. The largest quantity of alcohol which can be daily consumed without obvious injury was found experimentally by Parkes to be 2 ounces. The injurious reaction which follows alcoholic stimulation appears to be due to dilatation (from partial paralysis of their nerves) of the blood vessels after the primary stimulant effect upon the heart has ceased. Many diseases of the nervous centres and of the liver, stomach, kidneys, and blood vessels have been traced to the habitual abuse of alcohol; while, on the other hand, no real benefit, either in hot or cold climates, can be attributed to its use, even in moderation, unless in cases when food is deficient or when the alcohol is employed as a medicine. The drinking of arrack or other spirit, without food, is the most pernicious form of intemperance; and from the author's experience for some years at the General Hospital he believes that this form of intemperance is the cause of much disease, mortality, and misery in Madras, and that it is unhappily increasing year by year. Alcoholic drinks at best must be regarded as unnecessary luxuries and dangerous ones, because excess is not easily avoided.

Parkes, referring to the issue of spirit rations to troops, considered "that if spirits neither give strength to the body, not sustain it against disease . . . . then the medical officer will not be justified in sanctioning their issue under any circumstances."

Rations and Dietaries.

If the principles and facts already laid down be borne in mind there will be little difficulty in constructing rations suitable for any given circumstances or in detecting any deficiencies of existing rations; but this subject is one regarding which ignorance has so often resulted in widespread mortality that, even with some repetition, a separate section is here devoted to it.

---

* Dujardin-Beaumetz, 1886.

The question of diet is so frequently connected with that of disease and mortality, that in any case where excessive sickness and mortality—especially if due to bowel disease, scurvy or anæmia—is found to prevail among a population or in bodies of troops, or in jails or hospitals, the first suspicion of an experienced sanitary investigator is directed to diet.*

The constitution of one ounce of each of the principal food substances is shown in the following table in fractions of an ounce. It may be observed that this table is merely a repetition of the separate tables already given, with the decimal points of the numbers moved two places to the left so as to indicate fractions of unity instead of percentages. It will, however, be found of great utility in facilitating

---

* The following figures are given by Ewart to exemplify the influence of diet on mortality: deaths per 1,000 of strength of prisoners from diarrhœa and dysentery alone under old and deficient prison dietaries compared with deaths per 1,000 among comparatively well-fed sepoys:—

——	Bengal.	Madras.	Bombay.
Prisoners	21·65	16·99	15·07
Sepoys	1·63	2·10	2·09

Sickness and mortality in the Bombay House of Correction.

	Hospital admissions.	Deaths per 1,000 per annum.
Old bad diet	1,761	64·5
New improved diet	818	11·4

In another jail when the food was reduced from 45 oz. to 27½ oz. per diem, the mortality rose from 42·4 to 117·5 per 1,000. In this case the proportion of nitrogenous nutriment to carbonaceous was only 1 to 10.

The above instances are sufficient for the present purpose, but it may be mentioned that more recent examples could be given from the Madras Presidency.

the construction of dietaries to have all the figures in one conspectus:—

Table for calculating diets.

Food stuffs.	Proteid.	Starch or sugar.	Oil.	Mineral.	Fibre.	Water.
Cereal Grains.						
Rice	0·065	0·791	0·006	0·006	0·014	0·128
Koda	0·070	0·712	0·021	0·013	0·007	0·117
Ragi	0·073	0·732	0·015	0·023	0·025	0·132
Gundli	0·091	0·690	0·036	0·035	0·016	0·102
Maize (big joar)	0·095	0·707	0·036	0·017	0·020	0·125
Small joar (great millet)...	0·093	0·723	0·020	0·017	0·022	0·125
Bajra (kambu)	0·104	0·715	0·033	0·020	0·015	0·113
Kanga (tenai)	0·108	0·734	0·029	0·012	0·015	0·102
Varagu	0·126	0·694	0·036	0·014	0·010	0·120
Wheat	0·135	0·684	0·012	0·017	0·027	0·125
Amaranth	0·137	0·584	0·060	0·052	0·048	0·119
Leguminous Grains.						
Chick-pea	0·217	0·590	0·042	0·026	0·016	0·115
Mung gram	0·227	0·558	0·022	0·044	0·048	0·101
Pea	0·236	0·575	0·015	0·025	0·010	0·118
Lentil	0·249	0·595	0·013	0·022	0·012	0·118
Ground-nut	0·245	0·117	0·500	0·018	0·045	0·075
Soy bean	0·353	0·260	0·189	0·046	0·042	0·110
Animal Foods.						
Lean meat	0·183	...	0·049	0·048	...	0·720
Fish	0·160	...	0·050	0·010	...	0·780
Eggs	0·140	...	0·105	0·015	...	0·740
Milk	0·048	0·042	0·033	0·008	...	0·870
Blood	0·212	...	0·003	0·006	...	0·779
Starches and Sugars.						
Arrow-root	...	0·83	...	...	...	0·17
Sugar	...	0·945	...	0·005	...	0·050
Oils and Fats.						
Butter	0·040	...	0·810	0·025	...	0·125
Ghi and oil	...	...	1·000	...	...	...
Vegetables and Fruits.						
Starchy and Saccharine (potato or plantain) ...	0·025	0·211	0·001	0·013	0·010	0·740
Green and watery (cabbage)	0·002	0·058	0·005	0·007	0·018	0·910

Any ordinary rations can be easily and quickly reduced to their alimentary constituents by means of the above table: all that need be done is to multiply the quantity in ounces of each food-stuff contained in the ration by the numbers given opposite it in the table in order to obtain the quantity in ounces of its alimentary constituents. For example, the lowest Famine Code diet consists of 2 oz. of dhal and 20 oz. of cereal grain. If we suppose Bengal gram (chick-pea) and cholam (joar) to be used, we multiply each of the numbers opposite chick-pea in the table by 2 to obtain the quantities of proteid, &c., in 2 oz. of it, and similarly we multiply the numbers opposite joar by 20 to obtain the quantities in 20 oz. of it. This gives :

——	Proteid.	Starch.	Oil.	Mineral.
2 oz. Bengal gram ...	0·434	1·180	0·084	0·052
20 oz. cholam	1·860	14·460	0·400	0·340
Total value of ration ...	2·294	15·640	0·484	0·392

Now to ascertain the ratio of nitrogenous (proteid) to carbonaceous constituent in this ration we obtain the starch equivalent of the oil by multiplying the latter by 2·4 (0·484 × 2·4 = 1·16); this being added to the amount of starch gives 16·8 as the total weight of carbonaceous constituents, reckoned as starch. Dividing the weight of proteid into this $\left(\frac{16·8}{2·294}\right)$ gives 7·2; the proportion of nitrogenous to carbonaceous constituent in this diet is therefore 1 : 7·2, which is too low. The starch equivalent of the oil we have seen is 1·16 and the proportion $\left(\frac{16·8}{1·16}\right)$ which it bears to the total carbonaceous constituents is 1 : 14·5, this also being much too low. This ration is therefore very (though perhaps unavoidably) imperfect as it stands. Its defects might be corrected by (1) the addition of a little animal food rich in oil, or (2) of seeds rich in proteid and oil, such as ground-nuts or soy beans, or (3) by increasing the proportion of gram to cereal grain and adding the requisite amount of oil separately. Nearly ½ oz. of salt and some fresh vegetables would also be required.

In constructing rations for any given individual or group, the simplest plan is, in the first place, to determine the proportions of constituents and the absolute quantity of food required according to the circumstances of the case; secondly, to take a quantity of the staple food-stuff equal to the amount of food required; and, thirdly, having reduced this to its constituents, to substitute for a part of it such portions of available secondary foods as may be needful to give the proper ratios of constituents.

Cases sometimes occur in which only a few food-stuffs are available—possibly only one; and in such cases it may be impossible to apportion the constituents in due ratio. The only principle which can then be observed is to make sure that the food shall contain at least a sufficiency of proteid nutriment, even if other constituents have to be in great excess.

The question of expense is usually an important one in the formation of dietaries, and one which has to be carefully considered; it cannot here be entered into further than to state that it usually resolves itself into the substitution of the cheaper for the more expensive secondary foods and the limitation of variety in the diet.

To sum up, all the points which require attention when constructing dietaries are: available food materials, their composition and their cost; amount of food required, having regard to body weight, age, work, habit, and climate; proportions of alimentary constituents required, having regard to the same considerations; provision of fresh vegetable or fruit; provision of salt; variety; cookery; digestibility; allowance for waste; division of ration and hours of meals; arrangement of rations for groups of individuals. Sufficient has already been said regarding some of these points; those which have not been, or have been but partly, discussed must now receive attention.

Fresh vegetables and fruits are necessary, in all good dietaries, to prevent scurvy. They are also useful in giving variety of flavor and consistence to the staple articles of food and in promoting regular action of the bowels. If ordinary vegetables cannot be obtained, the leaves of any non-poisonous plants may be eaten as substitutes. Lime-juice is a good antiscorbutic; it is usually preserved by the addition of some spirit and is always carried in ships for use when fresh vegetables are not available. Dried or tinned fruits and vegetables may also be used with advantage when fresh are not procurable. 4 to 8 oz. per day is a moderate allowance of vegetables or fruit, though less may suffice for the preservation of health. Unless vegetables or fruit are used in larger quantities than this their diet value may be disregarded in calculating rations and serve as a sufficient allowance for waste.

The quantity of *common salt* to be added to a ration will depend upon the nature as well as the absolute amount of the food materials; for instance, salt fish or meat may require no such addition, while cereal grains and vegetables require most. Enough should always be used to make up, along with the *ash* in the food-stuffs, a sufficient amount of mineral food. The necessary quantity rarely exceeds half an ounce.

Other Mineral salts are necessary, especially phosphates of potassium and calcium, and their place cannot be taken by common salt. It is, therefore, improper to supply the mineral deficiencies of such food-stuffs as rice or sago by the addition of common salt only. When rice, or other food deficient in mineral matter, is the staple, it would be very desirable to adopt a practice which is said to be followed by some rice-eaters in Bengal, who use the ashes of gram plants along with their food. Any kind of gram or bean plant is well suited for the purpose, as such plants contain a large proportion of phosphoric acid. Habitual rice-eaters should employ the ashes of these plants, or of other green plants, mixed in the proportion of at least one-third with the common salt which they use as a condiment.

Variety in diet is an important consideration. Even when only one principal staple food is eaten, great variety of consistence may be obtained by different modes of cooking it, and variety of flavor by the use of various secondary foods and condiments. Thus even the poorest usually obtain considerable variety in their food. Indigestion and malnutrition are apt to result from a monotonous diet; and, in arranging dictaries, it should always be a practice to vary the food as much as possible. As a rule, it is not difficult to make some change for every day in a week.

Cookery is another subject which should engage attention. Good food is often rendered distasteful by bad cookery, while indifferent food is often made palatable by good cookery. Palatability is a very important matter; it is a familiar fact that savoury and well-cooked food "makes the mouth water," that is, it excites the flow of saliva and probably at the same time of gastric secretions, and therefore such food is readily digested as well as agreeable to eat. On the other hand unsavoury and ill-cooked food is apt to excite disgust, nausea and indigestion, or it may even be rejected by the stomach. Cookery is, to a great extent, a matter of taste and of habit, and varies among different races and classes; therefore, no very precise general rules regarding it can be laid down, except that it is better that most food substances should be too much rather than too little cooked. In imperfectly cooked joints of meat and loaves of bread the temperature in the centre of the mass is not sufficiently raised to destroy all organisms. Cooking, if thorough, will destroy all parasites in meat and also all bacteria, but not necessarily the poisonous products of the latter, so tainted meat cannot always be deprived of its power for harm and rendered safe to eat by cooking. During the process all albuminous substances are coagulated and connective tissues gelatinised, the cellulose coverings of starch granules are burst, thus allowing the digestive fluids to have access to the soluble interior of the grain, and the starch is partially converted into dextrin.

Regarding *digestibility* it should be noted that a fair proportion of indigestible material is desirable in food, in order that absorption of nutritive materials and intestinal action may be promoted by its bulkiness. A diet which consists almost wholly of digestible materials is apt to produce constipation and possibly contraction of the alimentary canal. Unusual or badly-cooked articles of diet, though nutritious in themselves, may, on the other hand, prove to be too indigestible.

Some allowance must always be made for *waste* in preparing food and for a portion of it which remains undigested 5 per cent. excess of alimentary constituents may be allowed on this account,* or, as previously suggested, the nutritive value of the vegetables in the diet should not be reckoned. From 5 to 10 per cent. of ordinary food stuffs is indigestible and forms the bulk of the excreta. The proportion is highest in the case of vegetable feeders who ingest a considerable quantity of cellulose which the digestive juices of man are unable to dissolve.

The *hours* and *number of meals* in a day and the division of the food between them are, to a great extent, matters of habit. Young children should have food at more frequent intervals than adults. Three meals a day is the usual number for adults in India (and in most other countries). A working man will ordinarily eat a light breakfast at 6 A.M., say ¾ lb. of porridge with salt and condiments and conjee-water, or perhaps butter-milk or a little tyre; at 1 P.M., dinner, a similar meal, with possibly a little curry; and at 8 P.M., supper, the principal meal of the day, consisting of about $1\frac{1}{2}$ lb. of porridge, pudding, or oil and fresh vegetables or gram or dhal, and occasionally fish or other meat.

---

* Church.

Rations for large numbers.

The construction of rations for single individuals or for families is not a difficult matter, but when large numbers of people, differing in weight, if not in age and habits, have to be fed, the subject becomes much more complex. We have seen that young children require a proportion of alimentary constituents and an absolute quantity of food relative to weight different from what is needed by adults. It is always necessary therefore to provide a separate diet for young children. Those over fourteen years of age may be treated as adults. With regard to the apportionment of diet according to weight, in an assemblage of adults, it is a prevalent practice to regulate the diet on the basis of the *average* weight of all the individuals. It follows that those who are above the average weight receive too little, while those who are below it receive too much food: in other words, about one-half of the people are under-fed and the other half over-fed. This method is therefore obviously not correct. If all the individuals of a group are to be sufficiently fed, the diet must be calculated for the weight of the *heaviest*. Thus considerable waste, or over-feeding of the majority, cannot be avoided in laying down a sufficient uniform ration for a large number of individuals. The waste or over-feeding may, however, be reduced to small limits by dividing the persons into classes, according to weight and giving a ration to each class based upon the greatest weight in that class. In weighing individuals for this purpose, excessive fat should not be reckoned, and judgment must be used in relegating adipose individuals to a lower class than their mere weight would accord them.

Finally, it may be stated that absolute accuracy is practically unattainable in constructing dietaries; but a near approximation to requirements can nearly always be made, and it should be a rule to err by excess rather than by deficiency.

PRESERVATION OF FOOD.

In this connection the main fact to be remembered is that decomposition does not occur in the absence of bacteria.

For their multiplication, moisture and warmth are necessary. Hence food-stuffs may be preserved by the exclusion of bacteria, by the addition of substances inimical to their growth, by desiccation, and by cold. The first method is illustrated by tinned foods. The substance to be preserved is sealed up in a tin, only a tiny hole being left open; it is then sterilised by heat and, while still hot, the small hole is soldered up. All organisms within the tin having been destroyed by the heat, and no others being able to enter, the contents will keep good indefinitely. The second method includes preservation by the addition of salt, sugar, oil, vinegar and certain chemicals. Fish and meat are preserved by salting and drying, and any food can be preserved by keeping it at a low temperature, below or near the freezing point of water. Bacterial growth is then inhibited and decomposition cannot occur, though most of the organisms present are not actually killed by the cold.

Preserved food is never quite as wholesome as fresh food and its use should be avoided when good fresh food can be obtained, not only on this account but also because the preservative process is not always carried out with due care with the result that decomposition occasionally occurs subsequently.

Unwholesome Food.

Articles of food, wholesome and nutritious in themselves, may be unwholesome for those who are unaccustomed to them, and, at first, cause indigestion and diarrhœa. Thus wheaten cakes or dhal often disagree with those who are not used to them. Again individual peculiarities occasionally occur: there are persons who cannot eat certain ordinarily wholesome substances, such as milk or fish, without suffering from colic or from nettle-rash.

The poisonous nature of some fishes and some leguminous grains has already been alluded to. It is probable that the flesh and milk of animals fed on garbage are also unwholesome.

Wholesome food may become unwholesome, or even actively poisonous, by decomposition. Thus mouldy grain or other food, or fruits, vegetables, and more especially animal foods, including milk, which have begun to decay are dangerous to eat.* Instances sometimes occur of fatal poisoning by such articles of food; the author has met with a considerable number of such cases, a few of which may be here mentioned: (1) stale cocoanut mare, six days old, caused poisonous symptoms in seven persons who ate it, and four of them died; (2) boiled peas, which were probably also stale, caused illness in twelve persons, two of whom died; (3) fried blood, some of which had been kept for a whole week before cooking, caused poisoning of twenty-five persons, five of whom died.† Colic, diarrhœa, vomiting, and collapse are the ordinary effects produced by decomposed food.

It is a common practice, among the poorer classes, in order to save the expense of a fire, to eat at breakfast, and perhaps also at midday, food which has been cooked on the previous day. Moist substances, such as boiled grain, porridge, tyre, and conjee-water may become unwholesome when thus kept, and communicable diseases may be propagated by them. Whenever food has to be so retained, it should be covered over and placed in a dry and clean place.

Uncooked or insufficiently cooked food is sometimes dangerously unwholesome. For instance, under-cooked dhal and grain of all kinds is very indigestible. Sweetmeats containing raw rice ought not to be eaten. The consumption of raw grain in large quantity may even cause death.

Foods preserved in tins occasionally become poisonous, though rarely to a grave extent, from the presence of lead or of tin. Copper, derived from the still, is commonly found in arrack,‡ occasionally in injurious amount. Copper poisoning not unfrequently results from cooking acid substances in copper utensils. Lead poisoning occurs occasionally owing to cooking pots being coated with that metal instead of tin. Lead poisoning has occurred in England among persons who used wheaten flour which had been ground in a mill in which a lead elevator was employed. It is not advisable that either copper or leaden vessels should be used in the preparation of food. A serious epidemic of arsenic poisoning in the north of England in 1902 was traced to the use of impure substances containing arsenic in the manufacture of beer.

---

* Not only man but other animals may be poisoned by mouldy food. Sir C. Cameron has published cases of both.

† Rept., Chem. Ex., 1884–86.

‡ Author; Chem. Ex. Rept., 1884, &c.

Several parasites may be communicated by food. Intestinal round and thread worms are sometimes acquired by swallowing their eggs with raw vegetables. Tape-worm is acquired by eating under-cooked meat containing its immature form (cysticercus); and *trichinæ*, and certain other parasites may also be conveyed to man in the flesh of animals infested by them.

Some microphytic diseases of animals, such as anthrax, may be communicated to man in a similar way. Hence meat, if at all suspected, should be very thoroughly cooked if it has to be used as food. Curiously enough it has happened or more than one occasion in Madras City, where the law regarding infectious diseases of animals is (1903) for various reasons practically in abeyance, that persons of the sweeper caste have, unbeknown to the sanitary authorities, intercepted the body of a horse dead from anthrax and conveyed it to their hutting ground, where with the aid of sundry caste fellows they have in one night skinned, cooked and devoured it all. Subsequent careful observation of the persons who participated in these orgies failed to detect any harmful result whatsoever.

ADULTERATION OF FOOD.

Manufactured or prepared foods are often adulterated. Some substances used as adulterants are injurious to health, and some may be offensive on other grounds, but all must be condemned as fraudulent. Some of the most common adulterations may be mentioned.

Milk, butter-milk and tyre, are commonly adulterated with water—often very dirty water, which may convey the germs of disease. Flour, plantains, and other substances have been employed to thicken milk thus adulterated What is sold as butter-milk often consists of little but water, and this is occasionally thickened with the juice of a plant (*Urœmia speciosa*).

Ghi is frequently adulterated with ground-nut and gingelly oils, and sometimes with animal oil. Some samples of ghi having been found adulterated with animal fat led to the passing of a special legal enactment in 1886,* and 37 out of 71 samples of ghi examined in Calcutta were found to be adulterated. In Madras ground-nut oil appears to be the most common adulterant of ghi.

---

* Bengal Act III of 1886.

Butter is adulterated most commonly with water and with fat. As much as 25 per cent. of water can be mixed with butter, and about this amount was found by the author in some samples supplied by a contractor to **a public** institution.

Grains and spices are nearly always purchased whole by the consumer in India, and are therefore not liable to adulteration, except with sand and dirt.

So-called foreign liquors are sometimes entirely fictitious and made up with common arrack variously flavored and colored.

Inspection of Food.

An organized inspection is manifestly important to check the sale of unwholesome or adulterated articles and the spread of disease by means of food. A competent food-inspector must be familiar not only with the appearance, odor and other qualities of good food-stuffs, but he must know how to detect bad ones and be guided by definite principles in condemning any article as unfit for food. A food-inspector, or even a medical officer, cannot be expected to perform a chemical analysis of foods—suspected articles must therefore be sometimes forwarded to a competent analyst for regular examination—but medical officers are occasionally able to make a useful microscopic examination of certain articles and to apply some qualitative tests. The most noteworthy points regarding food inspection and the examination of ordinary food-stuffs are here to be noticed.

In the inspection * of bazaars, markets, bake-houses, dairies, cattle pens and sheds, and slaughter-houses, the general cleanliness, provision of a pure water-supply, proper drainage and ventilation, regular conservancy, absence of foul or badly-made drains, latrines, dung-hills, or other causes of contamination of air, water, or soil, absence of disease among milch cows and among animals intended for slaughter, absence of infectious diseases among sellers and preparers of food or their servants or families, finally, wholesomeness and purity of all articles of food exposed for sale, are the main points which should engage attention.

---

* Inspections of this kind should be systematically provided for in bye-laws framed by local authorities under the provisions of Madras Municipal District Municipalities or Local Boards Acts. The "Model Bye-laws for Sanitary Authorities" issued by the English Local Government Board may be referred to. See also Mr. Jones's Manual, pp. 73, 74. Markets and slaughter-houses should be the property of the Local Authority.

Grain of all kinds is liable to become mouldy, therefore more or less poisonous and unfit for food, if kept in a damp place. Mould may be recognized by discoloration of the grain, the alteration of color being variable and depending on the kind of mould, by the presence of a peculiar musty odor, and, if the mouldiness be far advanced, by the adhesion of grains to one another in lumps. If the mouldiness be only beginning, spots of discoloration may merely be found on separate grains, or entire grains may be so affected. It occasionally happens that certain kinds of mould (as *smut* and *ergot*) attack grain while it is still growing. Mouldy grain should be condemned as food.

Grain which is stored in a damp place may sometimes germinate, or begin to grow, as evidenced by swelling of the seed and cracking or bursting of its outer envelopes, and perhaps partial protrusion of the embryo plant. Such grain should also be condemned as food.

Weevils or other small beetles sometimes attack corn and eat out the interior of the grains. A close examination of the grain will show the presence of powdery material mixed with it, and hollow seeds will be found which have been perforated by the insects. When the weevils are abundant there is little difficulty in discovering some of them. If a handful of the grain be thrown into water, the hollow grains and weevils will float on the surface. *Acari* are minute arachnids which attack grain in the same way. They may be seen by the assistance of a microscope and closely resemble the *acari* which cause itch. If very numerous, their presence is made evident by fine powdery substance mixed with the grain and hollow or partly eaten grains. Grain which contains only a few weevils or acari may be used at once, but if much infested by such insects it should be condemned.

New rice is unwholesome and may be recognised by the greater opacity and softness of the grains and by its cooking more rapidly and yielding a thicker cunjee than old rice. New rice cannot be condemned as food, but its use ought to be discouraged.

Flour of wheat or other grains may be attacked by mould or insects in the same way as the entire corn. It should not have an unusual color, or a mouldy or acid smell or taste, nor contain any lumps. Flour is liable to adulteration with the flour of other grains and with mineral substances. Wheaten flour when kneaded into a thick paste with water should be very tenacious and stringy. The admixture of the flour of various grains may readily be detected by the microscope, owing to the different appearance of the starch granules and coats of the seeds in each kind of grain. Mineral adulterations, if in any quantity, may be detected by shaking up a pinch of the flour in a small bottle with some chloroform, and allowing it to stand for some time: the flour, if pure, will all float on the chloroform.

Bread may be heavy and indigestible from bad toddy or other leaven, from the oven not being sufficiently hot, or from too much water having been used. The water should never exceed 45 per cent. and the bread should have no acid taste. Bread containing too much water soon becomes mouldy, and, like all mouldy food, must then be rejected. Bread adulterated with the flour of rice, etc., is less tenacious than pure wheaten bread. Bread made with mouldy flour is of a peculiar color and ought not to be used as food; a mould* was found in a specimen of dark blue bread examined by the author. Bakers sometimes add alum and more rarely copper sulphate to improve the whiteness and keeping qualities of bread made with bad materials. The latter is a particularly dangerous adulteration. Any medical officer may detect these adulterations by the following tests. Some of the bread having been burnt until only white ash remains, this ash is treated with a small quantity of solution of ammonia: if the liquid becomes blue, copper is present. A little tincture of logwood having been mixed with an equal quantity of a solution of ammonium carbonate, a crumb of the bread is placed in the mixture for a few minutes and gently dried; if alum be present it becomes bluish when dry, if otherwise brown.

In *vegetables* and *fruits*, discoloration and softening in patches or throughout are the well-known signs of decay, and all decaying vegetables and fruits should be rejected without hesitation. Over-ripe and unripe fruits should not, as a rule, be used as food.

---

* Probably *Ascophora nigricans.*

Milk, butter-milk, and to a less degree tyre, are very liable to be adulterated with water. Flour or other substance may also be dishonestly added. Any sediment which is found in milk should be subjected to microscopic examination; it may consist of impurities in added water, or of flour of some grain (which can be identified by its starch granules), or of blood, etc., from a diseased cow. The presence of added water in any quantity may be determined most readily by obtaining the specific gravity of the milk by means of a special instrument (hydrometer) or a urinometer, such as may be found in every hospital and dispensary, will answer the purpose. The specific gravity of milk ranges from 1,035 down to 1,026; if below the latter figure the milk should be condemned as watered. The specific gravity of milk is increased by about 2, by skimming off the cream, and it is lowered, by about 3, for every 10 per cent. of water added. In testing the purity of milk, it may therefore sometimes be desirable to determine the percentage of cream as well as the specific gravity. This may be done by using a long glass tube or jar, graduated into 50 equal parts, having filled it with the milk to the top mark, the cream which floats on the surface after four hours' standing should occupy at least 3 divisions (= 6 per cent.).

The specific gravity of curdled milk, tyre, or butter-milk may be easily determined by liquifying it by means of a solution of caustic alkali (potash or soda) of known specific gravity and taking the specific gravity of the mixture. For instance if the specific gravity of the alkali solution be 1,020 and the specific gravity of a mixture of equal parts of this and tyre be 1,025, it is evident that the specific gravity of the tyre must be 1,030.*

Besides being a perfect food for the child, and for the adult when reduced by disease, milk is also a perfect medium for the growth of most bacteria and fungi. Hence it is impossible to be too careful in preserving it from the access of all dirt and foul effluvia, and in seeing that the place of milking, udders of the cow, and hands of the milkers, are all to begin with scrupulously clean, and that all vessels used have been properly scalded. Secondly, bacteria take time to multiply, so milk should be used as soon as possible. Thirdly, bacteria do not grow well at a low temperature, so if milk has to be kept, the coolest available place should be selected and the vessel should be covered.

---

* This test, devised by the author, is included in the ready tests for ascertaining the purity of milk, butter-milk and tyre supplied to jails, contained in a Medical Department Circular, 1884.

The dangers of milk are not so much those derived from a diseased cow, such as tuberculosis, (tubercle amongst cows is very uncommon in most parts of India) but those added to it afterwards. Vessels are frequently rinsed out in dirty water, and milkmen will habitually keep as much water, obtained from the handiest source, in the bottoms of their tins as they can without detection : they have even been seen to scoop up some sewage from an open drain to dilute their milk. Such tricks favor the spread of cholera, typhoid and diarrhœa. The supply of milk in India suffers greatly from the poverty of the cow owner which will not permit him to start a dairy on approved principles. There is moreover a marked reluctance on the part of the natives to go into partnerships and to effect with united capitals what one alone could not attempt. This reluctance is at the bottom of the indifferent quality not only of milk but of almost every kind of food obtainable in India.

Meat may be unfit for food because it is decomposing or is diseased. A food-inspector should be well acquainted with the appearance of healthy animals, alive and dead. No beast which presents appearances of disease should be slaughtered for food ; but animals injured by accident may be eaten as a rule. "The animal's coat should be in good condition, the skin supple and free from scabs, pustules, or sores of any kind. The animal itself should be free from any discharge, and its breath from any offensive odor, while the breathing should be easy and noiseless. Its eyes should be bright, and it should give no signs of shivering or being in pain.[*] Lameness due to footsoreness, when animals have been driven far to market, is of no consequence.

Good meat should be neither too pale nor too dark colored—lamb, veal and pork are naturally paler than beef and mutton; it should be firm to the touch, and little or no fluid should exude from it; it should have an acid reaction (redden blue litmus); the fat and the marrow of the bones should be free from small clots or infiltrations of blood; the odor should be faint and not unpleasant; meat should not crackle on being pressed: this indicates the presence of air or gas, which may be due to decomposition or to a dishonest and reprehensible practice of some butchers who blow air into meat to make it appear more plump.

---

[*] G. Wilson's *Hand-book of Hygiene.*

Decomposing meat acquires an increasingly disagreeable odor, becomes soft and inelastic, and changes color first to a paler hue and later to livid and greenish.

Diseased meat is sometimes soft and flabby, with a juice which may be not acid; it may be too pale in color or else too dark and full of blood; the fat and marrow may be discolored, and present clots or infiltrations of blood; the odor may be unpleasant; decomposition usually sets in rapidly. The lining membrane of the chest and belly cavities should be examined for signs of inflammation which destroy its natural smooth and glistening appearance; healthy lungs are spongy, float in water, and present no solid patches, nor tubercles, nor abscesses, nor parasites; the spleen should not be enlarged nor softened; the liver should be free from abscesses and parasites.

The parasitic disease called *measles* in the ox and pig is recognised by the presence of small round bodies or bladders, about the size of a grain of cholam, in the flesh or in the liver or lungs of these animals. The little bladders are immature tape-worms; and, if the imperfectly-cooked flesh of animals containing them be eaten, they become developed into tape-worms in the bowels. *Trichina spiralis* is a minute worm which sometimes infests the flesh of the pig and may be communicated to man. Trichinæ can only be seen by the unaided eye as very small specks in the flesh, and a microscope is needed to reveal their true nature.*

Flukes are often found in the liver and other parts of beef and mutton carcases. They are easily destroyed by cooking and are not often communicated to man.

---

* I find no record of the occurrence of Trichinæ in Indian pigs.

Some kinds of fish, as already mentioned, are always and some others are occasionally poisonous. Parasites are extremely common in all fish. In 1883 a scare was created in Pondicherry, and spread to Madras, by rumours of dangerous parasitic diseases among fish; but, on investigation, no cause was found for the alarm.*

Flukes are specially common in fish. Fish, therefore, as well as other kinds of meat, should always be well cooked.

---

* V. Appendix B to Rep. San. Commr., Madras, 1883, by Deputy Surgeon-General M. C. Furnell. Professor Cobbold, who was referred to wrote: "All your marine fishes have entozoa, but probably none of these are injurious to man in India." Professor Huxley states that they "are easily killed by cooking."

CHAPTER III.

WATER.

IMPURITIES OF WATER.

PERFECTLY pure water is never found in nature. Natural waters always contain in solution some quantity of the gases of air and some solid matter, consisting of common salt and other minerals, and usually traces of organic matter derived from plants or animals. Besides such impurities *in solution*, natural waters always contain more or less impurity *in suspension;* suspended impurities consist of insoluble mineral matter, such as fine clay, and of organic matter, which may be dead or living. The dead organic matter found suspended in water consists of minute dead plants and animals, or small particles of larger plants and animals, in various stages of decay; the living organic matter consists of living plants and animals, many being extremely minute microscopic organisms, and of their seeds and eggs. Some of the impurities, which may be contained in water, are beneficial, whilst others are noxious.

Among beneficial impurities in water may be mentioned the gases of which air is constituted, especially oxygen. These gases (nitrogen, oxygen, and carbon dioxide) render water sparkling and of pleasant taste. Oxygen and carbon dioxide are proportionately dissolved by water to a larger extent than the nitrogen of air.* Oxygen dissolved in water, besides being necessary to support the life of fish and other aquatic animals, serves a very useful and important purpose in gradually oxidising and destroying the decomposing organic matter which may be dissolved or suspended in the water. Carbon dioxide gas dissolved in water affords nourishment to green aquatic plants in the same way that in the air it affords nourishment to green terrestrial plants, and it also renders soluble calcium carbonate, magnesium carbonate, and other carbonates which are little or not at all soluble in pure water. For the latter reason an excess of this gas is sometimes detrimental.

---

* The gases in water should consist of 8 to 10 per cent. of CO_2, 30 to 37 per cent. of O, 63 to 70 per cent. of N, the total amount of gases in a good potable water being from 25 to 50 cubic centimetres in a litre—*Dujardin Beaumetz.*

A moderate quantity* of calcium (lime) and alkali (mostly common salt) salts in water is not unwholesome and is probably beneficial in cases when the food is deficient in salts.

Water is rendered *hard* by calcium and magnesium salts and carbon dioxide gas, and its hardness depends upon the quantity of these impurities which it contains. Hard water does not easily wet the skin, nor wash off dirt from clothes, and much soap is required to form a lather with it. It is, therefore, even when fit for drinking, bad for washing purposes. It is also, unless the hardness be due to carbon dioxide only, bad for cooking, because vegetables and other food-stuffs cooked in it are tougher than if cooked in soft water. Hard water, of the same kind, is unfitted for steam and most manufacturing uses, and it deposits a crust or *fur* on the interior of boilers.

Water which has a saltish taste, usually due to common salt, is said to be *brackish;* but water, which is too brackish for drinking, may sometimes be fit for cooking.

Among suspended impurities, the presence of live fish, molluscs in moderate quantity, and large water plants, as well as of minute green algæ and diatoms, may be considered generally beneficial and purifying in rivers and shallow tanks, though they may exist in many bad waters. The absence of fish and molluscs in perennial rivers and tanks usually denotes very bad water.

The noxious impurities in drinking water are: (1) dissolved minerals in excessive quantity or of a poisonous nature, such as excessive quantities of calcium and magnesium salts, or even a small quantity of lead; (2) suspended mineral matters, such as clay or sand; (3) dissolved organic matter; (4) suspended organic matter, including vast numbers of micro-organisms. In the absence of harmful bacteria the mere presence of organic matter in water does not necessarily do harm especially if those who drink it are used to it: it is likely however to cause diarrhœa or otherwise disagree with persons who are used to a pure water. The micro-organisms found in water may be divided into two classes: (1) saprophytes which live in natural waters and are harmless; (2) parasites, which are not found in natural but only in polluted waters. The latter will be alluded to by the term *pathogenic* or disease causing organisms. The organic matter in water forms food for the micro-organisms, consequently, the purer a water the fewer the bacteria in it, and the number of bacteria found in a given volume of water can be said to roughly constitute a measure of the purity of that water. The basis of all endeavours to obtain a pure water in the first place, and to preserve it from all chance of contamination before it has arrived in the consumers' hands, is the fact that pathogenic micro-organisms are not found in waters uncontaminated with waste and foul matters derived from animal sources.

---

* Not more than 0·05 gram per litre of fixed solids.

The eggs or immature forms of various parasites may also be contained in polluted water and thence gain entrance into the human body where they become developed.

DISEASES DUE TO IMPURE WATER.

The principal physiological diseases which are ascribed to impure drinking water are diarrhœa, from mineral impurities such as magnesium or sodium salts or suspended clay; constipation, from excess of calcium or iron salts; stone in the bladder and goitre, from excess of calcium and magnesium salts; and lead poisoning, with dyspepsia, colic and paralysis from the use of leaden pipes and cisterns.

The principal microphytic or bacterial diseases communicable by water are cholera, typhoid fever, and various intestinal derangements grouped under the headings of diarrhœa and dysentery. It used to be thought that bad water was the agent for the spread of malaria, but no proof of any connection between the two has been brought forward.

The principal parasitic diseases communicable by water are those due to intestinal and other worms, the eggs, embryos or adults of which have accidentally been introduced. Such are anchylostoma duodenale, bilharzia hæmatobia, filaria medinensis (guinea worm), rhabdonema, leeches, filaria sanguinis hominis, distoma hepaticum (liver fluke), ascaris lumbricoides (round worm), oxyuris vermicularis (thread worm). The complete life history, however, of most of these parasites has not yet been worked out.

Besides the danger of communicating specific diseases, the habitual use of polluted water may produce a general impairment of health and increased liability to disease of all kinds.

SOURCES OF WATER.

Rain is the origin of all fresh water, except that obtained by distillation from salt water. By *rain water*, however, is usually understood only water which is obtained by the direct collection of rain on house-tops or other prepared surfaces. The rain which falls on the ground partly evaporates, partly flows over the surface, and partly sinks into the soil. The amount which evaporates depends on the temperature, dryness, and movement of the air, and rate and quantity of rainfall; the amount which flows over the surface or sinks into the soil depends upon the inclination of the surface and the nature and dryness of the soil, as well as upon the rate and quantity of rainfall. The water, which flows over the surface and in surface channels, carries all kinds of impurities with it into the tanks, shallow wells, and rivers, in which it finds storage or outlet, while that which sinks into the ground dissolves whatever soluble substances it may meet with in the soil, and, if sufficient in quantity, penetrates downwards until it meets with rock or impermeable clay, on the surface of which it flows slowly through the interstices of the porous soil, and forms the usual supply of wells. The height of this sub-soil water or ground water, as it is called, is shown by the level of water standing in ordinary wells; there may sometimes be none, and it may vary greatly at different seasons of the year and in different places. It is affected by the level of the water in neighbouring tanks and rivers. Its rate of flow depends upon the inclination of the impermeable layers over which it flows and upon the porosity of the permeable soil through the pores and crevices of which it has to pass. Sub-soil water is sometimes retained in basins or hollows in the impermeable layer on which it rests. When the surface of the land in any place dips to the level of the sub-soil water, this flows out, forming a spring. Springs may also be formed when water has, in an elevated part of the country, entered between two impermeable layers, which slope downwards into a lower part of the country, and any holes or fissures in the upper layer permit the escape of water through it. Very deep wells, which are sunk into a water-bearing layer of this kind lying under an impermeable layer, are called artesian* wells; the water in such wells often rushes up with great force, as may be seen at Pondicherry.

Drinking waters have been classified as to source and wholesomeness as follows†:—

Wholesome.	1. Spring.
	2. Deep well.
	3. Upland surface.
Suspicious.	4. Stored rain.
	5. Surface from cultivated land.
Dangerous.	6. River to which sewage gains access.
	7. Shallow well.

Water from any of these sources may be clear and of agreeable taste. Each of these natural sources of water has now to be considered.

Spring water is not likely to contain dangerous organic impurities: it generally contains very little organic matter of any kind, except when the spring is derived from alluvial soil; but it is sometimes highly charged with mineral matter, which may render it unwholesome for drinking or so hard as to be unsuited for cooking and washing. As a rule, however, spring water is excellent for drinking. Artesian wells may be regarded as springs.

Deep-well water.—A deep well, technically speaking, is a well that passes through an impermeable stratum of the soil and reaches a water-bearing stratum below. This water must necessarily have travelled some distance horizontally through the soil and is of great bacterial purity. If, therefore, it can be protected from surface pollution, it will be a good and safe drinking-water. Surface impurities can be excluded by building an impermeable masonry wall, or steining, from the surface down to the level of the impermeable stratum, so that surface washings cannot percolate through the soil and contaminate the water in the well.

Upland surface water is the surface drainage of hilly ground, and its nature depends upon the nature of the surface soil. The water is usually collected by channels passing along the bases of the hills and delivering into storage tanks or lakes.

---

* From Artois in France when the first celebrated one was sunk.

† By the Rivers Pollution Commission (England).

When the collecting surface consists of granitic or other igneous rock formations, with little vegetation and no habitations upon it, such water is very soft and pure. Most commonly, however, the receiving area is covered with jungle or grass, and the detritus of this vegetable matter is carried down with the water during the rains, some of it remaining dissolved or suspended in the water, while the heavier portion, mixed with clay or sand, forms the alluvial sediment or silt, which is deposited in the bottom of tanks and lakes. Water derived from a surface of this kind is soft and contains little mineral, but a considerable amount of organic impurity of vegetable origin. Of this nature are most of the tank waters in Mysore, Hyderabad and the Deccan districts. When the surface soil or rock contains soluble mineral substances they will be more or less dissolved by the water which flows over it; for instance, some surface waters in Salem and Bellary become thus impregnated with magnesium carbonate from *magnesite* rock, some in Coimbatore and other places with calcium carbonate from limestone rock, and some in the southern districts with nitre or with common salt from the soil. It must be remembered that upland surface water, if at all near a village, is habitually defiled by the inhabitants and by domestic animals, the banks of a tank being converted into a latrine and its water used indiscriminately for receiving ordure and urine, for washing the person and clothing and for drinking. Hence it is most necessary that any tank, the water of which is used for drinking, should be very strictly guarded from such pollution. Water derived from malarious jungles, or contained in nullahs, pools, or tanks in a malarious country, is possibly dangerous. With this exception, it may be considered that upland surface water, if guarded from animal contamination and filtered, if need be, to remove suspended vegetable impurity, is usually a good and wholesome source of supply.

Rain-water is systematically collected, in some parts of Italy and other countries, from the roofs of houses or from prepared areas, which are paved or lined with cement, and it is commonly stored in underground tanks. With due precaution, rain-water thus collected and stored is very pure and good for drinking, while its great softness renders it the best of all natural waters for washing. Rain storage, though not very suitable to large towns where the air is impure and dust abundant and where pollution of tanks might easily occur, would form the best possible source of supply for drinking purposes in those parts of the country where well water is brackish[*] or hard, and where pure surface water is not obtainable, and it deserves the special attention of the district and village authorities and all large householders in every place which does not possess a good supply of drinking water from other sources. In some cases, even where a good supply might be obtained from deep wells, rain-water storage may be found more economical both as to first expense and as to secondary cost of raising water. Deep wells are preferable for the one reason that they are less liable to filth contamination. If rain-water storage be adopted, it is essential that the cleanliness of the receiving area, filters and storage tank should be regularly attended to. The receiving area may be the roof of a house or a sloping surface of ground paved with stone or cement and enclosed by a wall or fence. A ground area is preferable to a roof because it is more easily inspected and cleaned. The size of the receiving area required to collect a given quantity of water in a year will depend upon the local rainfall, 25 per cent. being deducted for loss by evaporation, &c. The method of calculation will be described in the section on water-supply of villages. Rain-water thus collected contains impurities derived from the air through which the rain falls and the area upon which it is received, for the removal of most of these it should pass through a simple filter of gravel or sand before it passes to the storage tank. The capacity of a storage tank ought to be sufficient to contain enough water to last through the longest drought. The walls of the tank should be water-tight to prevent leakage and the entrance of impurity from outside, and the tank should be covered over, apertures being provided for ventilation and cleansing. The deeper the tank in proportion to its capacity, the less will be the loss from evaporation. Such reservoirs may, with advantage, be excavated in the solid rock wherever this is possible. The use of covering over a reservoir is not only to exclude dust and prevent fouling by birds and other animals, but to shut out light and heat, and thus to discourage the growth of vegetable and animal life in the water and to limit loss by evaporation. A depth of at least 14 feet is also advantageous in storage tanks, open or covered, for the same reasons.

---

[*] Cornish recommended its use many years ago in parts of Malabar where the well water is bad.

Rain-water, besides being stored in this way, may sometimes be usefully employed as a secondary source of supply to improve the quality of well water which is hard or brackish. For this purpose the collected filtered rain-water may be led into the well instead of into a storage tank.

Surface water from cultivated land is far more likely to be dangerously contaminated than water from any of the sources previously mentioned. The land around villages is commonly fouled by the inhabitants who resort to the edges of fields or their neighbourhood for purposes of nature and wash themselves in irrigation streams. Such water is usually also polluted with the ordure and urine of domestic animals and with whatever manure is applied to the land; besides which it is certain to contain much vegetable detritus and perhaps mineral impurity. Therefore, it should never be used unless no better water is obtainable, and then it should always be purified by filtration and boiling. Water from cultivated land which is not manured and has no houses or villages upon it, may be of good quality.

River water is always dangerous in India, except the water of mountain streams in uninhabited localities. During the rains, all kinds of surface dirt and filth, which has accumulated in nullahs, is washed into rivers, and the water is also turbid with suspended clay; and at all times the water of rivers and canals, which pass near villages, is polluted by the inhabitants. Sometimes dead bodies are cast into streams, or buried or burnt in their beds when the water is low. River water should, therefore, not be used if better water be obtainable, and if it has to be used it should be carefully purified. Deep wells sunk in or near rivers sometimes yield good water.

Shallow wells.—The quantity of water obtainable from a shallow well depends entirely on its surroundings. Here again we use the term "Shallow" in a technical sense. In a shallow well no impermeable stratum is passed through before reaching the water. Nevertheless a "shallow" well may be in certain districts actually deeper than a "deep" well in other districts. There is nothing to prevent surface impurities reaching the water in a shallow well; even an impervious steining is only partially successful in this respect.

Shallow well water is usually the worst of all waters. Some of the shallow wells in or near villages are no better than cesspools, and the people often drink their own diluted ordure and urine, mixed with those of domestic animals, and the washings of their bodies, clothes, and household utensils, along with all the other dirt which may find its way into the water from the surface and from the air. What wonder that such people are never free from intestinal parasites, and that they are debilitated and die by millions from diarrhœa, dysentery, cholera, and fevers? What wonder that their soil should be "the breeding-ground of cholera"?* Wells or small tanks which are more or less protected from direct surface contamination by masonry walls or steps are much better than ordinary shallow wells, but even they are liable to constant pollution from the feet of those who draw the water and from dirty utensils, and owing to their large open mouths they collect dead leaves and dust from the air in large quantity. One of the most urgent and primary sanitary measures required everywhere in India is the filling up of surface pools and dangerous shallow wells. While such sources of disease and death remain patent in every direction, municipal and local boards can have no excuse in not finding profitable employment for all the funds which are at their disposal for sanitary purposes.† If much water be drawn from a well, the level of the water in it is lowered below the general level of the ground-water; the latter, therefore, for some distance around, flows towards the well and becomes depressed in the shape of a funnel with curved sides of which the surface of the water in the well is the apex. All the drainage which filters through the soil above this funnel-shaped depression of the ground-water must pass into the well, and any surface pools or deposits of filth within a considerable distance around a well are thus likely to contaminate its water. The more a well is used, the deeper and wider becomes the depression of the ground water, and the more likely is such contamination to occur. Lining the upper part of a well with impermeable masonry does not protect it from this. It is true that surface filth may have to pass through a considerable thickness of soil before it reaches a well, and it may thus be effectually filtered for a time; but if the surface pollution be continued, the soil eventually becomes contaminated throughout and it ceases to act as an efficient filter. Fissures in the soil may even allow of direct communication between wells and drains, sewers, surface pools, or other sources of contamination. The distance, at which surface contamination may affect a well, depends upon the local circumstances of each case. The height and direction of flow of the sub-soil water, the depth of a well and the amount of water drawn from it, and the nature of the soil are the principal circumstances which have to be taken into consideration. No possible source of contamination should ever be allowed to exist within 20 or 30 yards of a well, and this is often much too near to be safe. One eminent authority * considers that "the well should be at a distance of not less than 200 yards from the nearest house or drain, or cesspool, or other source of sewage pollution." Wells should not only be placed at the greatest possible distance from any source of contamination, but on that side of it, from which the sub-soil water flows. If it cannot be ascertained in what direction the water moves, it may be taken for granted that it is with the general slope of the surface of the ground, such being usually the case. The upper portion of a well ought to be lined with impermeable masonry to prevent the entrance of direct drainage from the upper layers of the soil, which are the most impure. The ground should be made to slope away from the mouth of a well, and be paved with impermeable masonry for some distance round the mouth to prevent surface drainage from finding its way directly into the well or down on the *outside* of the masonry tube of the well. As an additional safeguard against such occurrences, the soil around the tube of the well ought to be puddled to as great a depth as possible. In places where the ground water is high, the level of water in wells must also be high; but even in such places there is much difference between deep and shallow well waters, although the water may stand at the same level in both. The shallow wells receive the surface drainage which may have passed through only a few feet of probably polluted soil; the deeper wells, with a water-tight masonry tube, tap the lower layers of ground water which have filtered through a considerable depth of soil. It may be suggested that in such cases it would be advantageous to sink wells on the tops of any hillocks or high ground, so as to prevent surface percolation and obtain water filtered through the greatest possible thickness of soil. It is advisable that the mouth of a well should be small in order to prevent the entrance of dead leaves, insects, dust, and impurities of all kinds as much as possible. For drawing water from a well, a pump or a public bucket should be provided, and no person should be permitted to employ a private vessel for the purpose; such a vessel may be dirty and perhaps introduce disease germs into the water Wells require to be cleaned out occasionally, and provision should always be made for this, which may be most conveniently done at the end of the hot weather when the water is lowest. The water of a well, which has not been cleaned out for a long time and has not been in constant use, will be found to contain an excessive quantity of organic matter. If a well has been disused for some time, it should always be cleaned before being again brought into use. With attention to the above mentioned points deep wells form one of the best possible sources of water-supply.

---

* The ancient Hindus were apparently more careful in avoiding defilement of water. Menu and the Shastras frequently inculcate personal cleanliness and ablution; but Menu also says that no man should cast into tanks "either urine, or ordure, or saliva, or cloth, or any other things soiled with impurity, nor blood, nor any other kind of poison." (Kanny Lall Dey.)

† "Sanitary allotments made by Municipal Councils amounted, in 1884, to six lakhs and-a-half . . . . Of the total allotment, only Rs. 3,84,751 or 58·7 per cent. had been expended before the close of the year." (Government Order, Madras, 19th August 1885, No. 1956, Public.) Matters have since improved a little.

---

* *Dr. Frankland.*—Evidence before Committee of House of Commons on Public Health Amendment Bill, 1878.

The main thing to bear in mind is that wells are by far the most frequently polluted by their mouths. Hence the necessity for a good parapet wall and an impervious platform around. The notion that well water must be exposed to the light and air if it is to be good is entirely erroneous; still, it is widely prevalent and is always brought forward as an argument against closing up the mouth of a well and introducing a pump. The water in a well with a closed mouth is both safer and better than that in a well with an open mouth. An ordinary suction pump theoretically lifts water 33 feet, but practically it cannot be depended on to lift more than 25 feet. Force pumps which will lift any height are sometimes made use of in urban areas, but in villages the more primitive windlass and bucket will probably be found to be the most suitable form of lifting apparatus.

Norton's tube well.—For the temporary supply of water in camps and during festivals this device is frequently useful. It consists of a steel pointed tube with perforations near its end which is driven into the ground at a spot where water is known to be and where the soil is not polluted. Lengths of tubing are screwed on to the first piece, and the whole is driven down by blows from a falling weight suspended on shears till the required depth is reached, when a pump is fitted to the top. When no longer wanted the tubes are withdrawn.

To lessen the chance of pollution from without, Koch recommended that all wells should be fitted with an iron tube and then filled up with gravel and sand. The water is withdrawn by a pump at a little distance connected with the tube.

Useful facts to remember in connection with water are the following :—

One gallon of water weighs 10 lb. (70,000 grains).
One cubic foot of water weighs 62·3 lb.
One cubic foot of water measures 6·23 gallons.

Collection of water.—As it is extremely important that people should be supplied with plenty of pure water, and as it is usually impossible to obtain it pure from wells or tanks in towns, it is frequently necessary to have recourse to artificial storage tanks where rain water can be collected or a stream dammed back in a valley. Sometimes a natural lake suffices. Whatever the method employed may be it is of the utmost importance that the catchment area, drainage area, or gathering ground of the storage tank should be carefully preserved from contamination, that is to say, that no human habitations should be permitted to exist within the area, that grazing of cattle be prohibited and that cultivation be stopped, for where there is cultivation there there will be men and beasts, and the land will be manured from time to time.

Another method of obtaining sufficient water to supply a town is by means of infiltration wells or galleries. A number of ordinary wells are sunk in a water-bearing stratum at a distance from the town and in unpolluted ground, and the water is pumped up and delivered by pipes directly, or better through the medium of a storage tank. The "Seven Wells" supply of Fort St. George, Madras, is an illustration of this method, but the stratum which formerly supplied pure water has become polluted and the water is no longer safe for drinking. In other cases galleries are cut alongside a sandy river and unjointed or perforated pipes are laid at the bottom and covered in with coarse gravel. Water from the river filters through the intervening thickness of sand, being purified on the way, and is pumped up to a storage tank and then distributed. The ground water flowing towards the river is also intercepted by the gallery. The neighbourhood of such a collecting area must be carefully preserved from contamination. Several southern Indian towns derive their supply from some such source as this.

The presence of fish in a storage reservoir does no harm, and the larger water plants tend to purify the water by giving off oxygen under the influence of sunlight. Certain small water weeds, such as nostoc, and some minute unicellular algæ, often evolve most offensive odours. It sometimes happens that these minute algæ increase enormously in tanks, and later on, the conditions becoming unfavourable to them, they die off with equal rapidity, and decompose and greatly pollute the water. There is no remedy for this state of affairs but removal of the growth if that be practicable. A foul tank in a town can often be purified and rendered inoffensive by introducing some large water plant, such as the lotus.

Smaller *storage tanks* in towns should be of masonry, well covered in to keep out dust and bird droppings, and at the same time well ventilated. House storage cisterns should be of masonry, stoneware, or galvanised iron, covered in, ventilated, and fitted with a tap to avoid the necessity of dipping possibly dirty vessels into them. Water kept in earthen vessels placed on the ground runs great risk of becoming contaminated, and all cisterns below the level of the floor of a courtyard should be condemned. Surface waters are generally improved by being stored in open reservoirs or tanks as oxidation of the contained vegetable organic matter goes on, but sub-soil waters undergo rapid deterioration from the growth of algæ, unless kept in the dark. Deep well waters are not improved by storage; bacteria gain access and multiply greatly. No such multiplication is found in stored surface waters. The growth of bacteria and fungi is encouraged by dark storage.

NATURAL PURIFICATION OF WATER.

Purification of water constantly occurs in nature. Sub-soil water is surface water which has been purified from suspended matter by filtration through the earth. Organic impurities, whether suspended or dissolved in water, are gradually destroyed by oxidation, the oxygen which is dissolved in all natural water being the main purifying

A. J. Sawy

agent. The oxygen of the air also acts directly upon impurities at the surface. Water in commotion becomes much more rapidly purified than still water, because the impurities are constantly being acted upon by fresh portions of oxygenated water after they have removed the oxygen from the portions of water with which they were first in contact, they are exposed to atmospheric oxygen as they are tossed about on the surface, and the water is kept well oxygenated by free exposure to air. The presence of certain microphytes appears to be necessary for the destruction of many organic impurities ; putrescent nitrogenous matter is converted by them into ammonia, and this is further converted into nitric acid. The action of sunlight in purifying water has probably been overestimated ; though it will destroy bacteria growing in a test tube, it is hard to estimate what effect it has in turbid water a few inches below the surface. Sedimentation plays a large part in the natural purification of water. Organic and inorganic suspended matter gradually settle to the bottom and the former is in time nitrified. It must be remembered that water is not the natural habitat of pathogenic organisms such as those of cholera and typhoid, and though they may live and multiply for a while they gradually tend to die off when introduced. In addition they have to contend against the saprophytic bacteria naturally found in water in the struggle for existence. In deep wells and sterile water, which contains no saprophytes, they may however survive for months.

Artificial Purification of Water.

Our forefathers were content with the *physical* purification of water. As long as it was clear and bright and tasted well they were satisfied. Further knowledge led to care being taken to obtain *chemical* purity by the removal of dissolved noxious substances. Latterly great attention has been paid to securing *biological* purity ; the freedom of water from the micro-organisms which are the cause of disease, and to this end all our efforts must be directed. 1. By *distillation*, water is obtained nearly absolutely pure, organisms are destroyed, the solids are left behind and dissolved gases only pass over. This method is used for obtaining potable water on boardship, and in places where little or no fresh water exists, such as Aden. Distilled water is, however, unpalatable unless aerated. 2. *Boiling* drives off the dissolved gases of water, including CO_2, whereby chalk is precipitated. Bacteria are killed, but not necessarily all their spores. The worst water can however be rendered safe to drink by boiling, and it is a process which should never be neglected whenever the purity of the water obtainable is questionable. It has the disadvantage of rendering the water less palatable until it has been again aerated, and it is tantalising when thirsty to have to wait until the boiled water cools down. It is of course useless to boil water and to cool it down by the addition of cold unboiled water. Both boiled and distilled water when cooled must be carefully preserved from contamination, since no living bacteria are present, and any which find entrance will, therefore, be able to multiply unhindered.

3. *The addition of Chemicals.*—(1) Alum added in solution in the proportion of about 6 grains for every gallon of the water to be treated forms in hard waters a bulky precipitate of aluminium hydrate which settles to the bottom and carries with it much of the suspended matter, including bacteria. Care should be taken not to add more alum than is actually required to form a precipitate, otherwise the water will be rendered unfit to drink. The water should be poured off as soon as subsidence is complete, as those of the sedimented organisms that have not perished rapidly multiply and find their way back into the water.

(2) Clark's process is designed to remove the temporary hardness, *i.e.*, dissolved chalk, from the water by precipitation. Lime water is mixed in by mechanical means and this combines with the CO_2 which holds the chalk in solution, and causes the chalk to be precipitated. The precipitate is allowed to settle or is strained off. The permanent hardness due to the presence of sulphates, nitrates and chlorides of calcium, magnesium and sodium is not affected by this process.

It is exceedingly important to remove as much of the hardness of water as possible for dietetic reasons, and, especially of a public water-supply, to prevent the incrustation of boilers, and wastage of soap. In cooking with a hard water, lime salts are deposited on the surface of the material, which hinders extraction in the case of tea and renders tissues hard in the case of meat and vegetables. Sodium carbonate softens water for washing, but cannot be used in cooking.

(3) The vaunted Indian clearing nut (*strychnos potatorum*), the juice of prickly-pear leaves, and such like

substances, may be practically neglected except as household remedies when nothing better is available. The former contributes a bitter and the latter a sickly taste to the water.

(4) Potassium and sodium permanganates readily part with their oxygen in the presence of oxidisable organic matter in water and gradually render it harmless. Permanganate is used for purifying the water of wells and small tanks. It is supposed to have a specific action on the cholera bacillus and many medical officers have reported most favourably on the influence it has had in controlling epidemics of cholera when the water supplies have been systematically treated with it. Others, including the writer, have not noticed any great change for the better which could fairly be ascribed to its use. In the extremely dilute solutions in which it is generally used it is hardly likely to injure the cholera bacillus itself, but it may indirectly affect it by oxidising its food materials in the water. A handful of the salt should be dissolved in a vessel of water and the solution added to, and thoroughly mixed with, the water in the well under treatment. As oxidation proceeds the pink colour disappears, and the only test that a sufficiency of the salt has been added is a pink coloration of the water which lasts not less than 12 hours.

The water is in no way injured by the process as the salt is non-poisonous, but the pink solution has a faintly disagreeable taste. The coloration and taste have their advantages in that they tend to keep people from using that particular well for a time.

To destroy bacteria a 5 per cent. solution of the salt is required. This renders the water quite unfit for drinking for a long time, and if the treatment of water is being carried out on a fairly large scale, the cost of the salt generally will prohibit its use in this strength.

Many other processes having in view the purification of water and involving the use of different chemicals and special apparatus are in use in various parts of the world, but for the present at any rate they seem to be inapplicable in India.

4- *Filtration.*—The object is to remove all suspended matter mineral and organic, including bacteria. The dissolved constituents of the water are also in some degree changed. On a large scale for the purification of a town water-supply filters are almost universally constructed of sand and gravel after the model of the earth, which is one of the best filtering

2 " sand
1 foot water

media known. A sand filter consists of a layer of clean sand 2—3 feet in thickness supported on a bed of gravel about 3 feet thick. The area depends on the quantity of water to be filtered. The depth of water above the surface of the sand should not exceed 1 foot and the rate of filtration should not be greater than 6 inches of water per hour. This allows 2½—3 gallons to pass through each square foot of filtering surface per hour. When first brought into use, the water passes through the filter unpurified. Gradually the interstices become obstructed and a slimy or gelatinous layer forms on the surface and the filtrate becomes purer, until, when working at its best, from 95—98 per cent. of the organisms present are arrested. The slimy layer increases in thickness and the rate of filtration becomes slower and slower until it becomes necessary to clean the filter. This is accomplished by removing the slimy substance and the upper half inch or so of the sand, and thus the cycle goes on. At intervals, varying with the amount of sediment in the water under treatment, the whole of the sand has to be removed, cleaned and renewed. The slimy layer consists of finely divided mineral and organic matter, bacteria and algæ. The action of such a filter is partly mechanical and partly vital, and the removal of bacteria from the water is effected by their arrest in the fine meshes of the slimy layer, the formation and preservation of which is therefore the essential feature of the sand filter.

Animal charcoal, spongy iron, polarite and numerous other substances have been used as filtering media, chiefly on a small scale in *domestic filters*. Some of these act mechanically and others chemically, by oxidation, but none can be depended on to remove organisms; in fact unless carefully looked after by some one who understands them, they are liable to become breeding grounds for bacteria and to actually increase the number of organisms in water that has passed through them.

If a town water-supply is properly filtered before delivery the use of domestic filters is to be discouraged as unnecessary and at times even dangerous. The filters provided at the stations of some of the great Indian Railways must be classed as useless if not actively dangerous fixtures. Filtering through cottonwool, closely packed in a glass or tin funnel, is a ready and useful way of removing the coarser suspended impurities from water, but bacteria are not arrested by this medium. The "three chatty filter" so frequently seen in Southern India, if in the possession of a person educated to look after it, may serve a useful purpose, but as it is generally used it can only be condemned as leading to a false sense of security. If the public water-supply is unfiltered and open to suspicion domestic purification becomes a necessity. Only two ways of removing bacteria are certain: (1) by boiling, (2) by the use of filters of the pattern of the Berkefeld or Pasteur-Chamberland. These consist of cylinders or "bougies" or "candles" of porous material through which water is forced under pressure or by the action of gravity. The pores are sufficiently fine to arrest all bacteria while allowing the water to pass through, and it is consequently obtained quite sterile. The bougies can be adapted to fit common water taps, for use in a force pump for travelling, or as ordinary filters actuated by gravity. These types of filter differ from one another chiefly in the size of their pores, the bacteria which are arrested on the outside grow through sooner or later and appear in the filtrate. The larger the pores the more rapid the rate of filtration and at the same time the more rapidly are bacteria able to grow through. The more sediment in the water the more frequently is cleansing necessary to remove the deposit on the outside which obstructs the flow of water through the bougie. Sterilisation of the bougie by boiling or other means is also necessary to destroy organisms which are growing through the pores. In the case of a Berkefeld filter which has the coarsest pores, sterilisation should be performed every third day; of the Pasteur-Chamberland, once a week. Though mostly used as domestic filters, these forms are now fitted up in "batteries" for the purification of water in aerated water factories, and even for the filtration of a public water-supply as at Darjiling. It will be seen then that, while properly used, the Berkefeld and Pasteur-Chamberland filters are capable of giving a bacteria free water, if their action is not understood they cannot be expected to yield a safe water continuously.

WATER-SUPPLY OF TOWNS.

The question of water-supply for large towns need not occupy much space here, because it is a question which should in every case be referred to the consideration of highly-trained sanitary and engineering experts. Some knowledge of it, however, must be regarded as indispensable for all municipal authorities.

The water should, as a rule, not be derived from any source within a town. Surface wells should on no account be used, and any which exist ought to be filled up with earth. Even deep wells situated in towns are very liable to pollution ; the more they are used, the more likely are they to be fouled, for, according as the water is lowered, the area drained by a well is increased ; and the chances of direct pollution are manifestly greater in towns than in the country. Rain-water collected in large towns is also apt to acquire dangerous impurities from dust in the air and dirt on the roofs of houses. The water-supply of towns should, therefore, be obtained from a pure source outside. Springs, deep wells, up-land surface water, and filtered river-water are the sources from which towns may be supplied ; and the source available or the one selected where there are several must depend upon local circumstances in each case. With regard to quality, it is desirable that water for a public supply should be not only free from dangerous organic and mineral impurities, but that it should be soft. Hard waters are not good for washing nor generally for manufacturing purposes, and they may cause blocking of pipes from calcareous incrustation ; while the only possible objection to soft waters is that they are more likely to act on leaden pipes. The quantity of water required per head of population depends largely upon local circumstances, such as the use of public and private baths, water-closets and latrines, sewerage, clothes-washing, manufactures and road-watering. Domestic animals have also to be provided for, and good drinking water is necessary for their health.*

Clothes are frequently washed in very foul water, and the construction of public troughs or wash-houses, supplied with pure water, for the use of washermen free or on payment of a small rent, is a matter which deserves the attention of municipalities.

There is always a good deal of wastage in public water-supplies, and much of this is often preventable by proper control. Such control is most necessary when the supply is limited, or when the water has to be pumped up at considerable expense or to be purified, or when it is important to limit the quantity of sewage out-flow.

---

* Not only to prevent parasitic, but other diseases also ; as an instance, not long ago a valuable pack of hounds was nearly destroyed by an epidemic of disease which Mr. Mills, A.V.D., pronounced to be dog typhoid. The water, which they drank, was found by the author to be polluted with house-refuse and to contain swarms of bacteria.

In cases where the supply of good water is limited, it may be necessary to use it only for drinking and cooking, water for other purposes being obtained from less pure sources. A dual supply of this kind is, however, very objectionable, because it is certain that careless people will use for all purposes the water which is most easily obtained.

The quantity of water required for drinking and cooking may be set down as 1 gallon per head of population daily, and for all purposes 12 gallons per head is a sufficient, and 15 gallons an ample, supply for a town, if waste be prevented. With a large margin for waste and ornamental fountains and gardens, 30 gallons or more may be used.

Aqueducts or channels for conveying water require great attention to prevent fouling of the water in them. The Romans carried pure water from great distances into towns by solid masonry aqueducts, laid sometimes underground and sometimes supported on lofty arches according to the level of the ground. These aqueducts were so well built that the city of Rome still possesses a copious supply of excellent water delivered by several of them. Large iron pipes are now generally used for the purpose and they are found more convenient and less expensive, as they may be carried over undulating ground and support considerable pressure. They should, however, be bedded on firm foundations to prevent leakage of joints, and valves or taps must be provided at the summits of upward and the bottoms of downward curves to allow of the removal of air or of silt. Open channels such as that leading from the Red Hills to Kilpak * are very objectionable; and can never be properly preserved. For delivery of the water in the town, iron pipes should be employed. Lead pipes or cisterns should be generally avoided in India, for most Indian waters contain a considerable amount of nitrates and may become poisonous by contact with lead. Peaty waters are very apt to attack lead. Hard waters, and especially those containing silica, are not likely to dissolve lead. Unfiltered muddy water, such as Red Hills water at some seasons, is apt to cause choking up of pipes from silt, and some kinds of hard water produce the same effect by a deposit of calcareous material

---

* In Madras.

on the interior of the pipes. Fish or other animals alive or dead may enter water-pipes with unfiltered water or through leaky filters* and cause stoppages in pipes or pollution of the supply. Hence it is desirable to filter all public supplies before distribution.

Water-pipes, especially in a descent,† are likely to admit gaseous, liquid, or even solid impurities through leaky joints; care should, therefore, be taken not only to provide solid foundations for such pipes, but to avoid laying them in polluted soil or close to sewers. If this cannot be avoided, the pipes should be bedded in concrete.

The distribution of water in a town should be such as to place an abundant supply within easy reach of every house. Numerous public fountains situated at convenient centres will be found sufficient and safest in most cases; but, if the supply be constant, separate supply pipes may be laid to private houses and public buildings, and the pressure of water ought to be sufficient to carry it to the top of the highest building in the town.

Taps should be inserted at convenient intervals in the water mains laid through streets, in order that a ready water supply may be obtainable for extinguishing fires and, if possible, for watering the road ways. The supply and pressure of water should be as *constant* as possible. An *intermittent* supply is very liable to contamination: when the water is shut off foul air or liquid and even solid matters are likely to be sucked into the pipes through leaky joints or open taps.‡

If, for repairs or other reasons, the supply has to be shut off for a time, danger may be obviated, when the water is turned on again, by leaving some of the terminal taps open until the pipes have been sufficiently flushed.

In cases where there is a threatened failure of the water-supply of a town, owing to a long drought or other cause, the common and, as above pointed out, dangerous practice is to render the supply intermittent by shutting it off except during certain stated hours daily. Danger would be avoided and waste would be better controlled if, instead of shutting off the main supply, municipal authorities were, in such cases, to seal up a number of the least required taps and fountains, and, if necessary, to limit the flow of taps by the insertion of perforated plugs or some similar device.

---

* Eels have lately obtained access to the pipes of one of the London water companies in this way and caused much annoyance. Fish are sometimes found in Madras water pipes.

† Buchanan in Rep. on Croydon Supply.

‡ There are several well authenticated cases in which this has occurred, and in which disease has been thus distributed.

To render the water-supply of a town perfect it is necessary, not only that an abundant supply of pure water should be distributed to every part, but that every local source of polluted water should be closed. It is well known that numerous foul wells and tanks exist in Calcutta, Madras, and other cities and towns, which possess a comparatively good public supply of water, and that the inhabitants make free use of such contaminated sources, even in the close vicinity of public fountains. So long as filthy and contaminable * sources of water are allowed to exist within municipal limits, no town, however pure and abundant its supply may be, can be considered well supplied with water or safe from outbreaks of those diseases which are communicable through water.

The calculation of water-supplies for towns, the construction of weirs, storage tanks, well-tunnels, &c., and many other matters relating to large water-works are peculiarly the province of sanitary engineering experts and cannot be discussed here.

Water-supply of Villages.

The town population bears only a small ratio to the rural population in India; the water-supply of villages therefore demands even more attention than that of towns. Towns can generally command the services of specially-trained and experienced sanitary and engineering authorities; but villages have in most cases to depend upon their own or their district officers for advice and supervision regarding the water-supply, and, indeed, for sanitary improvement generally. Hence it is most important that those officers should be capable not only of giving advice, but of carrying their advice into practice. Many portions of the preceding remarks as to the qualities and sources of waters and the water-supply of towns are equally applicable to the supply of villages and detached houses, and they should be borne in mind when reading the following observations which are particularly intended for village authorities and house-holders.

We shall consider the water-supply of villages with regard to source, quantity, purification and distribution,

---

* A word coined, I believe, by Sir John Simon.

premising that combined action on the part of the inhabitants will usually be required to secure a really satisfactory and safe supply.

Existing sources should first be examined and their water should be tested with the view of deciding whether one or more of them may be used for a general supply and whether they are capable of improvement or not.

Springs are rarely available, and the choice of good sources will generally be between deep wells, stored rain, and upland surface water. Deep wells and upland surface water have been already sufficiently discussed. Stored rain water is, however, such a valuable source, and one so little used in India, that some further remarks upon it may be useful. From this source pure drinking water could be readily obtained in places where well waters are brackish or unwholesome from their hardness and the presence of magnesium or other mineral impurities or from organic impurity, and where surface waters are liable to contamination. Such places exist in nearly every district. Large surfaces of rock may sometimes be utilized as collecting areas, the water being received in a channel cut along the lower edge of the surface and delivering with the intervention of a small filter into the storage tank. If a rock surface is not available, stone or brick may be employed for paving the selected area, or its floor may be puddled, and lined with mortar, or what is better, Portland cement. The surface ought to have a sufficient incline to allow the rain to run off rapidly, and thus limit the loss by evaporation. The prepared area must be surrounded by an impenetrable fence or high wall, to prevent its defilement by men or other animals. A prepared surface of this kind is better than a house roof for collecting rain, being more easily inspected and cleaned, and a roof is not generally large enough to yield a sufficient supply. It may be found convenient in some cases to use both roofs and ground areas. If it be determined to supply a whole village with rain water it is much better to have one large properly-made collecting surface and storage tank, which can be more easily looked after and kept clean than several small ones.

The *quantity of water* required, and the consequent size of the collecting area, will depend upon whether water for all purposes, or only for drinking and cooking, is to be supplied from this source. In places where the rainfall is sufficiently abundant, and where a large collecting surface can be provided, it may supply water for all purposes, at least 5 gallons per head (including children) daily being allowed. In places where the rainfall is scanty, or where long periods of drought are frequent, it may be possible to supply only water for drinking and cooking purposes from it, at least 1 gallon (8 pints) per head being allowed. To calculate the size of the collecting surface required, the first thing to ascertain is the average rainfall for as long a series of years as possible. If no observations of rainfall have been made at the place itself, the records of the nearest meteorological station may generally be accepted. One inch of rainfall yields a little more than a half gallon (0·5198) for each square foot of surface. The method of calculation can best be explained by an example. Let us suppose that it is required to obtain a supply of 5 gallons per head daily for a village containing 450 inhabitants, the average annual rainfall of the place being 28 inches. The total quantity of water required in the year will be the population multiplied by the daily amount per head multiplied by the number of days in a year, $450 \times 5 \times 365 = 821{,}250$ gallons. As each inch of rain yields half a gallon on a square foot, 28 inches yield 14 gallons on each square foot and $821{,}250 \div 14 = 58{,}661$, which is the area in square feet necessary to collect the required supply. As an allowance for wastage by evaporation, leakage, &c., 25 per cent. may be taken, thus making the area $\frac{58{,}661 \times 4}{3}$ or 78,215 square feet, that is, a space measuring, if square, $\sqrt{78{,}215}$, or nearly 280 feet on each side.

The average annual yield in gallons of any existing surface may be calculated by measuring its *horizontal* area in square feet, multiplying this by half the average annual rainfall in inches, and deducting one-fourth for wastage. If the incline of the surface be slight no allowance need be made for its divergence from a horizontal plane; but if the incline be considerable a correction must be made, for instance, a pointed roof must be reckoned as a flat roof, covering the same house. Any surveyor, or other person accustomed to take levels, can easily make the required calculations for a ground surface.

The construction of a *storage tank* for rain water has already been alluded to: its capacity has now to be discussed. In most part of India very little rain falls during the first six months of the year: storage for at least six months' supply will therefore be required. The rainfall of the driest year likely to occur may be taken at not less than half the average rainfall, and in such a year only half the usual supply would be collected. It may therefore be generally reckoned that a good storage tank ought to have a capacity equal to nine months' supply—that is, three-fourths of the annual requirements. In the case above supposed of a village with 450 inhabitants requiring 5 gallons each daily, or 821,250 gallons in a year, the storage tank ought to have a capacity of $\frac{821,250 \times 3}{4}$, or 615,938 gallons, or nearly 98,700 cubic feet. (6·24 gallons = 1 cubic foot.) A reservoir, 23 feet deep, 23 feet wide and 172 feet long, would have the requisite capacity, and it should, if possible, be covered over. In any case it should be protected by a fence.* Storage tanks ought to be built in two or more compartments for convenience of cleaning.

Although unfortunately the circumstances of few Indian villages would admit of the construction of reservoirs of this kind to supply 5 gallons per head daily, yet many villages could probably afford to construct reservoirs to furnish drinking water only. An area and tank of the size mentioned would be sufficient to supply drinking water only (1 gallon per head per day) for a population of 2,250 persons.

If the catchment area were considerably increased, so as to take better advantage of occasional showers during the dry season and light monsoons, the storage tank might be made smaller still. If this were done, and if care were taken to restrict the consumption to actual requirements in times of drought, a storage tank to contain only a four months' supply (at 1 gallon per head daily) might be made to suffice in many places.

Smaller reservoirs would be very useful in places where deep wells yield a good supply at certain seasons of the year, but occasionally run dry. The reservoir could be filled from the well and used as a reserve source when the well ceased to yield.

A less costly plan† than that of masonry tanks would be to store the water in an ordinary bunded tank, with sides and bottom puddled, allowing for increased evaporation and other loss by enlarging the catchment area and storage capacity.

---

* Works of this kind, being permanent improvements, ought to be constructed when needed by Taluk Boards, the capital expenditure being made repayable by instalments spread over a considerable number of years.

† Suggested by my friend, Captain H. D. Love, R.E., to whom I am also indebted for revisions and corrections in the foregoing paragraphs.

Existing small tanks might in some instances be improved and utilized, at no great expense, so as to furnish a supply of usable, if not very pure, water protected from contamination. For this purpose the tank should be deepened, both it and a sufficient catchment area being well puddled, to render them water-tight, and tank and area being surrounded by a good fence. An intercepting drain would also be required in most cases to prevent surface water, except what flowed from the prepared area, from entering the tank. The growth of aquatic plants would be beneficial, and should be encouraged in a tank of this kind if it be shallow.

Surface water collected in open tanks, may be sometimes employed ; but it is very difficult to preserve open tanks from pollution when they are situated near villages. Surface water, even if collected from an unpolluted surface, must, at all events, contain a good deal of vegetable impurity, and it requires more careful filtration than rain-water collected on a prepared area. No fixed rules can be laid down for the calculation of the quantity of water obtainable by collection in an open tank from a surface which is not water-tight ; it depends largely upon the porosity or inclination of the soil and the depth of the tank.

The supply which a well is capable of yielding may be estimated by pumping out a large quantity of, or all, the water, measuring the space from which the water has been removed, and observing the time which it takes to fill again. The cubic space (contents) may be calculated by multiplying the cross area (horizontal section) of the well by the depth of water removed. Wells are generally circular or rectangular in cross section : the area of a circle is the square of its diameter multiplied by 0·7854, and of a rectangle its length multiplied by its breadth. Say, for instance, the water in a circular well, 3 feet in diameter, is found to be 12 feet deep. A mark is made to register the water level, and the well is pumped dry. The time from the cessation of the pumping until it fills again to its former level is noted, and is, let us suppose, five hours. $3 \times 3 \times 0{\cdot}7854 = 7{\cdot}07$ the cross area of the well in square feet; this multiplied by $12 = 85$ cubic feet nearly, the contents of the well. Now 1 cubic foot $= 6{\cdot}24$ gallons; the contents are therefore 530 gallons ; and, this quantity being yielded in five hours, the quantity which can be yielded in twenty-four hours will be (5 : 24 :: 530 : x) 2,544 gallons. It must always be remembered that the yield of wells may vary greatly according to season and in different years.

The yield of a small stream may be ascertained by noting the time it takes to fill a vessel of known capacity, or by digging a pit of certain dimensions, turning the stream into it, and noting the time it takes to fill.

In the *distribution* of village water-supplies various improvements are feasible. The present ordinary plan of drawing water in private vessels should on no account be allowed, because impurities, including the virus of some diseases, may be thus conveyed to a well and distributed in its water. A public bucket with a rope and windlass, or a pump, is much safer. A still better arrangement would be to build a cistern at a convenient level, and have it filled once or several times daily, from the well or rain-reservoir or tank, by means of a pump or other mechanical elevator worked by public cattle, or by hand or water power or a windmill. When wind or water power is employed, provision should generally be made for the use of cattle when wind or water fail. The people could then obtain water from the cistern tap without any danger of polluting the source. For larger villages the water might be raised at the source, be carried into the village by pipes or an aqueduct and be distributed to one or more public cisterns or fountains placed at convenient centres. A good public supply for villages could thus usually be managed at no great expense, and it would very largely contribute to the health and convenience of the inhabitants.

When a public supply is provided one of the village officials should have charge of it and be held responsible for its efficiency, and for the periodical cleansing and repairs of collecting surfaces, wells, storage tanks, filters, cisterns, &c.

Examination of Water.

Although an acquaintance with general and practical chemistry is necessary for well-qualified sanitary specialists, it is not to be expected that sanitary or medical officers in general, who are not experienced in chemical methods and manipulations, should be able to make an accurate quantitative analysis. Every Sanitary officer of superior grade should certainly know enough of chemistry to clearly understand the analytical methods employed, and it is necessary that all should at least be able to read a water analysis intelligently and to make a simple examination of the quality of a water. The following observations are therefore divided into two parts:—Firstly, description of an easy method for the examination of water; secondly, inferences to be drawn from complete examination by an expert. These observations have been made as simple as possible, in order that they may be readily understood and utilized by person who possess little or no chemical knowledge.

Easy Method of examining Water.

The question of the *quantity* and sufficiency of the supply at all seasons has already been fully treated of; the examination of water as to *quality* only has now to be considered. This may be divided into (1) local, (2) physical, and (3) chemical examination.*

The *local examination* should consist of a careful survey of the source, method of raising if any, storage tanks, methods of purification, cisterns, and channels of distribution, with particular reference to any possible or probable cause of pollution. The Sanitary Inspector or person who collects a sample of water for examination is in a position to play no unimportant part with regard to its passing or condemnation by the analyst. The latter working at a distance can only judge of the condition of the supply by the result of his chemical analysis of the sample sent to him. This may give no indication of present danger, and nothing but a careful local survey can decide whether the supply is likely to be a safe one or is exposed at times to chances of serious pollution.

After this a sample of the water should be taken for physical and chemical examination. A stoppered (Winchester quart) bottle is convenient for the purpose, or two ordinary bottles with clean new corks may be used. Great care must be taken to use perfectly clean bottles. The bottles should be washed out with the water to be tested before they are finally filled with it. A fair sample of the water should be secured in the exact state in which it is drunk. It ought to be examined as soon as possible after collection, and be shaken up, if there be any deposit in the bottles, before it is poured out for testing.*

---

* For the simple and physical and chemical examination of water here described the following apparatus should be provided:—A Winchester quart bottle, two tall jars or bottles of white glass, a few large test tubes, blue and red litmus paper, and solution of potassium permanganate, Nessler's reagent, silver nitrate, barium chloride, ammonia, ammonium oxalate, metaphenylamine diamine, brucine, dilute sulphuric, nitric, and hydrochloric acids, and strong sulphuric acid, in stoppered bottles.

The *physical examination* includes observation of the clearness, color, taste, odor when fresh and after keeping, of the water; also (if the examiner be skilled with the microscope) a microscopic examination of the sediment. A tall jar or bottle of white glass should, if possible, be used for examining the clearness and color of a water, the jar being placed in a good light upon a sheet of white paper, a considerable depth of water may be viewed by looking downwards through it. If the water be very turbid, the depth through which ordinary newspaper print can be read may be stated. It should also be noted if any distinguishable objects, such as bits of leaves or insects or small worms, alive or dead, are present. If there be any sediment it should be observed whether it be compact or flocculent. If no color or turbidity be apparent a second glass vessel of the same size filled with distilled or other very pure water may be placed beside the vessel containing the water under examination, and the two waters can then be compared.

The taste may be readily ascertained without swallowing any of the water. To detect the odor, if any, a clean wide-mouthed bottle should be half filled with the water and shaken; on then smelling the mouth of the bottle any odor will be evident. If no odor be perceptible, the bottle half full may be stoppered and set aside for twenty-four hours, when it should again be shaken and smelled, or, if it be desirable to complete the examination at once, gently warming the water, or the addition of a few drops of caustic potash solution to it, may cause the development of some odor.

Microscopic examination will not, as a rule, form a part of this brief investigation; but, if the observer be a medical man, and be provided with a microscope, he may usefully examine any sediment. Angular particles of sand or rounded ones of clay, fragments of vegetable tissues, of insects, reddish or brownish masses of decomposing organic matter, living infusoria, or evidences of contamination with house refuse, such as starch granules of rice or other grain, portions of vegetables used as food, epithelial scales from human skin, human hairs or fibres of cotton or wool from clothes, may thus be recognized.

---

* This has been the rule in the Chemical Examiner's laboratory at Madras for some years. The author has found different practices prevalent in various laboratories, in some the heavier suspended matters being allowed to subside for twenty-four hours, in some filtration through paper being adopted, and in others what he believes to be the correct practice of shaking up any sediment.

Qualitative Chemical Examination of Water.

Reaction.	Test with red and blue litmus papers.	Acid turns the blue red, and alkali turns the red blue.
Chlorides.	Add dilute nitric acid and silver nitrate solution. A white precipitate.	1·4 parts per 100,000 give a haze. 6·0 ,, ,, turbidity. 14·0 ,, ,, a precipitate.
Sulphates.	Add dilute hydrochloric acid and barium chloride. A white precipitate.	4·0 ,, ,, a haze. 8·0 ,, ,, a precipitate.
Calcium (lime).	Add ammonium oxalate and boil. A white precipitate.	9·0 ,, ,, turbidity. 16·0 ,, ,, a precipitate.
Ammonia.	Add Nessler's solution. Yellow or brown color or precipitate.	Much ammonia if color is marked.
Nitrous acid (nitrites).	Add metaphenylamine diamine and dilute sulphuric acid. Yellow color on standing.	1 part in 10,000,000 gives a yellow color in $\frac{1}{2}$ hour.
Nitric acid (nitrates).	Add brucine solution and shake. Then pour strong sulphuric acid down the side of the tube so as to form a layer at the bottom. A pink and yellow zone is formed where the liquids meet.	Pink zone obtained when ·7 parts per 100,000 are present.

For the organic matter test two white glass bottles, a solution of potassium permanganate (1 grain to 2 ounces of water is strong enough), and some distilled, or other water known to be pure, are required. The bottles should be marked to indicate equal measures, otherwise a glass measure will also be needed. In one bottle a measured quantity of distilled water is placed and in the other bottle an equal quantity of the water to be examined. Solution of potassium permanganate is added, drop by drop, the drops being counted, to the distilled water until it acquires a distinct pink tinge which remains after it is stirred with a glass rod or the bottle is shaken. The same number of drops of potassium permanganate solution must be added to the water in the second bottle, and mixed similarly. Both bottles are then placed on a sheet of white paper and their color is compared for a quarter of an hour. If the water under examination loses its pink color rapidly, it contains a considerable amount of organic matter, probably animal; if it loses its color more slowly, the organic impurity is more probably vegetable; if its pink color remains with little change, it contains little organic impurity.

The inferences which may be drawn from an examination of water according to the above scheme have now to be explained.

A yellow or green color generally denotes organic impurity which may be injurious, and a brown color may be due to clay or peat which are comparatively harmless. A deeply colored water ought always to be rejected unless the cause of its color can be ascertained to be harmless. A markedly turbid water must necessarily be condemned Flocculent sediment is usually organic. A badly smelling water is probably dangerously contaminated with organic matter and not fit for potable use. Any marked taste is usually due to excessive mineral impurity which must also render the water unfit for use.

The color, turbidity, odor and taste of water, may thus serve as sufficient causes for its rejection; but a perfectly colorless, clear, odorless, and tasteless water, which is to all appearance very pure may contain dangerous organic and mineral impurities. It is evident therefore that although physical examination alone may be sufficient to condemn a water, it is not sufficient to pass it as good and wholesome.

Microscopic examination of the sediment may reveal the presence of house refuse or other dangerous contamination which must condemn a water; but, as above stated, the absence of such visible impurities does not imply that the water is pure.

Any water which has passed the physical examination must therefore be further examined chemically.

A strongly acid or any alkaline reaction should condemn a water unless the cause is known to be harmless.

Water which rapidly decolorizes potassium permanganate must be regarded as dangerously polluted with organic matter (unless it is known to contain iron).

Ammonia is usually derived from the decomposition of nitrogenous organic matter. Any water containing it in quantity is therefore probably polluted, and if a well marked color be given with the test solution the water should be condemned. Slight traces of ammonia are found in most waters.

Chlorides are contained more or less in all natural waters. If the quantity be large, it shows that the water is brackish (from common salt derived from the soil) or that it is contaminated with animal impurity. Thus a considerable amount of chlorides alone cannot condemn a water; but a very small quantity is an indication of a very pure water.

The presence of sulphates in sufficient quantity to give any turbidity with the test solution is evidence of dangerous mineral or organic contamination which is enough to condemn a water.

The presence of nitrites indicates recent contamination of the water and should lead to its condemnation. Nitrates are evidence of past contamination, and, if the quantity of ammonia and organic matter is at the same time small, need not render a water unfit.

The foregoing method of examination affords a fair basis for giving an opinion as to the usability of a water. If the results of the local, physical, and chemical examination be satisfactory the water may be pronounced usable; if otherwise, it must be regarded as suspicious or dangerous. In the case of doubtful water it is advisable to obtain a complete analysis, or at all events never to use it without purification. If a water be condemned on account of turbidity or of organic impurity it should be set aside for twenty-four hours in order that the sediment may subside, or be filtered, and then examined again to ascertain if it may be rendered usable when purified by subsidence or filtration.

Complete Examination of Water.

A complete examination of water involves full investigations as to (1) *quantity*, storage and distribution, and (2) *quality*, protection from defilement, and purification. Enough has been said to enable the reader to judge of reports under the first head; and, under the second head, it only remains to point out the inferences which are to be drawn from chemical analysis and from microscopical and biological examinations made by experts, and to explain the value and uses of such analyses or examinations.

The ordinary analysis of drinking-water made in the laboratory of the Chemical Examiner at Madras comprises the determinations which are stated below. It must be noticed, however, that no absolutely fixed rule can be laid down, and the origin of impurities, if it can be traced, must be taken into account.

Quantitative Analysis of Water.

In a good water the various constituents should be within the limits stated below:—

Total solids	Should be under 10 parts per 100,000. (*a*) *fixed*; salts of metals, silica. (*b*) *volatile*; organic matter, ammonia, nitrites, nitrates, should be under 1·5 parts per 100,000.
Chlorine	1·5—3 parts per 100,000.
Hardness	*Total*; 30 parts per 100,000 or 21 degrees (Clark's scale). A good soft water contains less than 5 parts per 100,000. Permanent hardness under 3 parts per 100,000.
Nitrates	Less than 1·5 parts of nitric acid per 100,000.
Nitrites	*Nil.*
Free ammonia	·002—·005 parts per 100,600.
Albumenoid ammonia	·005—·01 parts per 100,000.
Sulphates	Under 3 parts per 100,000.
Phosphates	A trace.

Total combined nitrogen (nitrates, nitrites, ammonia).	Under ·4 parts per 100,000.
Oxidisable matter (oxygen absorbed in 15 minutes at 80° F. from potassium permanganate).	0·5—·1 parts per 100,000.

A short account must now be given of the meaning of each of the above determinations and the inferences which may be drawn from it when considered singly or in conjunction with other determinations.

The *total solids* comprise all the solid impurities of water, suspended and dissolved, organic and mineral. The mineral impurities are comparatively heavy, and, as a rule, form by far the largest proportion of the solids.

Chlorine is usually due to the presence of common salt in the water. It may be derived (1) from the sea or the soil, in which case the permanent hardness is likely to be considerable and the free and albumenoid ammonia and volatile solids may be small in quantity, or (2) from animal pollution, especially urine, in which case free and albumenoid ammonia and volatile solids will indicate recent and dangerous contamination. In the first case a considerable quantity of chlorine may be harmless.

Total hardness affords little indication of the wholesomeness of a water, since water is rendered hard by such harmless impurities as carbon dioxide and calcium carbonate as well as by noxious salts of calcium and magnesium. Hard water is not well suited for washing, cooking, and steam purposes.

Permanent hardness is a much more valuable indication, because it is entirely due to noxious mineral impurities, principally salts of calcium and magnesium.

Free ammonia, if in large quantity, is usually derived from the decomposition of urine and other animal matter, chlorine and nitrates being also increased, if such be the case, and albumenoid ammonia existing in some quantity.

Albumenoid ammonia is a measure of the actual nitrogenous organic matter existing in the water. If albumenoid ammonia be considerable and there be little or no free ammonia, the impurity is probably of vegetable origin, and if chlorine be also absent or in very small quantity it is almost certainly vegetable. Albumenoid ammonia co-existing with free ammonia, chlorine, and nitrates renders it probable that the impurity is of animal origin and therefore most dangerous.

Nitrates are the final result of the decomposition of organic nitrogenous matter, being formed by the oxidation of nitrites. In India nitric acid is frequently derived from nitre deposits already existing in the soil and therefore it cannot be regarded as a trustworthy index of organic contamination.* It renders water likely to act on lead.

Phosphoric acid is sometimes estimated, and its presence in water is a more certain indication of organic pollution than that of nitric acid.

Much free ammonia in shallow well water indicates pollution with urine: in a deep well nitrates, ammonia and chlorine may be present in considerable quantities without indicating danger, provided that oxidisable matter and nitrites are absent.

The ordinary microscopic examination of water may detect evidences of house refuse, or eggs or embryos of parasites, or vegetable detritus, and thus sometimes discover the source and exact nature of contamination. Bacteria and fungi, if abundant, indicate the presence of decomposing organic matter. Other microscopic organisms, animal or vegetable, ought not to be numerous in good drinking water.

The foregoing information should be sufficient to enable a sanitary officer who has but a slight knowledge of chemistry not only to arrive at some definite conclusions with regard to the fitness of any water-supply for drinking purposes, but also to intelligently interpret the report of the detailed quantitative analysis of the Chemical Examiner and to be able to explain it to the Municipal Council or local authority he may be serving.

The chemical analysis of water has however its limitations. It can determine the amount of added impurity and declare that a water is dangerous, but cannot show that a water is safe. Though chemically pure a water may contain pathogenic bacteria in sufficient numbers to start an epidemic. The chemical examination must therefore be supplemented by a bacteriological examination with the object of ascertaining the number and, if possible, the species of bacteria present. Owing to the enormous number of saprophytic bacteria often present it is frequently impracticable to isolate pathogenic organisms from a water, so the bacteriological test as a rule resolves itself into an enumeration of the number of organisms present in a given volume of water, irrespective of their nature, on the principle that the more bacteria there are, the more likely is it that some of them will be of harmful species. No definite line can be drawn as to the number of organisms permissible, but to have some sort of standard it may be said that the number should not exceed 100 per cubic centimetre in filtered water. Far more importance must be attached to the species present than to the mere number. The methods employed for the detection of these organisms cannot be entered into here: they are beyond the range at present of those for whom this book is intended. A water cannot be sent to a distant laboratory for bacteriological examination without special precautions. It is best that the work be done on the spot; if this be not possible the sample must be put at once in ice in a specially constructed box. The reason is that the bacterial contents of a sample may enormously increase in a few hours at air temperature and if the examination be delayed an entirely false idea of the water may be entertained. For instance in a sample examined at the time of collection Frankland found—

---

* My experience in this matter agrees with that of Surgeon-Major Nicholson. *Vide* Lancet, 20th October 1883.

In the morning	7	bacteria per cubic centimetre.
At the end of the day . .	21	,,
On the third day . .	495,000	,,

Value and scope of water analysis.—The principal uses of single or repeated analyses may be stated as follows:—A single analysis is necessary to ascertain the nature and quantity of the impurities in any sample of water. Repeated or periodical analyses are necessary (1) to determine the changes in water from the same source under different seasonal or other conditions, (2) to detect contamination and possibly indicate its origin, (3) to ascertain the best means and to test the continued efficiency of means adopted for purifying water.

A water should not be condemned unless the source of every suspicious substance found in it is known, but it is only when the chemical, microscopical, and bacteriological examinations are all satisfactory, together with the history of the water, that it may be said to be safe. It must be remembered, however, that the purest waters are liable to accidental contamination and outbreaks of disease may then follow.

Ice should be manufactured from the purest water available and a factory should have its own filters if the public supply is open to suspicion. Bacteria are not destroyed by the temperature of frozen water, they merely cease to multiply, and when the ice is melted their vitality is restored and they grow with vigour.

The manufacture of aerated waters requires the strictest supervision not only as regards the water put into the bottles, but as regards the premises and arrangements for washing the bottles. Only the purest water should be used, since neither the pressure nor the presence of dissolved carbon dioxide gas has much adverse influence on the vitality of bacteria, at any rate during the time within which the aerated waters are usually consumed.

CHAPTER IV.

AIR.

COMPOSITION OF AIR.

THE atmosphere or air which surrounds the earth is a mixture of gases, consisting of 79 per cent. of nitrogen and 21 per cent. of oxygen by volume. It also contains normally a small amount (0·03 per cent.)* of carbon dioxide gas, traces of ammonia and nitric acid, and a variable quantity of water in the form of vapour. The air gradually diminishes in density as we ascend from the surface of the earth, and it does not appear to extend beyond 200 miles from the surface.

The quantity of watery vapour which air is capable of containing varies with temperature and with barometric pressure. At the average pressure at sea level and within the ranges of temperature met with in Madras, 1 cubic foot of air is capable of holding from 6 grains, at lowest temperature, to 12 grains, at highest, of watery vapour (14 to 28 grams per cubic meter). The amount of moisture which is most agreeable and generally best for health is about 60 per cent. of the quantity required for saturation of the air. This subject has to be further alluded to in the section on climate.

Nitrogen, of which the air is principally composed, possesses no active properties. Oxygen is essential for the support of animal life. Its main function is to oxidize (a process chemically analogous to burning) food substances which have been absorbed, and thus to evolve animal energy and heat. The proportion of oxygen in air varies a little in different places, being slightly less in towns than in the country. Traces of a condensed and very active form of oxygen, termed ozone, exist in very pure air, but not in the air of crowded places.

Carbon dioxide (carbonic acid gas) is given out abundantly in the respiration of animals, and to a less degree of plants, and it is absorbed by the green leaves of plants and decomposed by them under the influence of light, the carbon being retained and oxygen liberated. The proportion of carbon dioxide varies to a small extent in pure air, but in crowded places it is considerably increased. This gas is evolved from lime-kilns, from the combustion of wood, coal, and organic matter generally, the chief source perhaps being decaying organic matter mostly vegetable in origin. Men have been suffocated by it when incautiously sleeping near lime-kilns, or approaching places where large quantities of gunpowder had just been exploded in blasting, or after explosions in coal mines, or in descending into old wells and holds of ships.* Air containing much more than 5 per cent. of carbon dioxide will not support life, and 1·5 per cent. in air will cause head-ache.

---

* The air in towns contains more nearly ·04 per cent. of carbon dioxide.

IMPURITIES OF AIR.

Natural air, like natural water, is never pure. It is being constantly polluted, but it is also constantly being purified by various agencies. Air is rendered impure by 1. respiration, 2. emanations from the skin and excretions of animals, 3. by putrefaction of organic substances, 4 by combustion, 5 by exhalations from the soil, 6 and by dust consisting of various mineral and organic materials. It is purified by the 1. diffusion of gases, 2 dispersion of impurities by wind, the 3 action of plants, 4 oxidation, 5 rain and dew, and 6 gravitation 7 which causes the substance of dust in still air. The impurities of air may be considered in two classes; (1) gaseous, analogous to dissolved impurities in water; (2) suspended, like suspended impurities in water..

Of gaseous impurities excess of carbon dioxide has already been mentioned. Gases which are chemically poisonous or irritant are sometimes evolved from factories, such as brick-kilns and cement, alkali, smelting and various chemical works. Fetid organic gases, often of ammoniacal nature, emitted from putrefying materials, may exert poisonous effects. Gaseous impurities in air are rapidly diluted and rendered harmless by diffusion and dispersing currents of air. Those which are soluble in water are also carried down by rain, and complex organic gases are gradually oxidised or decomposed into simple compounds.

---

* A lighted candle may be used to test the purity of the air in such places before men enter them. If the flame be extinguished, it is certain that the air will not support life.

Suspended solid impurities are everywhere present in air, and are, as a rule, much more dangerous, as well as more widely diffused than gaseous impurities.* Mountain air and sea air are most free from them. They may be mineral or organic. Mineral, or inorganic, suspended substances consist of dust raised by the wind or thrown up by volcanoes, minute crystals of common salt derived from sea spray, carbon from smoke, and particles of metals or other materials arising from certain trade processes. Dust has been known to be transported by wind for hundreds of miles, and it is believed that the dust thrown up in the great eruption of Krakatoa in 1883 was diffused through the entire atmosphere of the earth.†

Mineral dust in air is apt to cause diseases of the air passages and lungs (bronchitis, asthma, emphysema, and destructive lung diseases), and in trades, such as mining and grinding metal implements, where much dust is produced, the average lifetime of workmen is shortened and lung diseases are more than usually prevalent. This is particularly the case when the particles of dust are hard and angular. The dust arising in certain trades may be chemically poisonous, for instance white-lead from paint-grinding, arsenic also from certain paints, antimony from printing type, &c.

Organic suspended matter in the air may be dead or living. The former consists of vegetable fibres and fragments, bits of insects and other animal fragments, and dried excrement. It can do no particular harm. The latter includes bacteria, fungus spores and pollen grains. Aerial bacteria are mostly saprophytic. The air is not the natural habitat of any living organisms since they can obtain no nourishment there. Still they are always present being most numerous in dirty places and during dry weather.‡ They are particularly numerous in places where the soil is foul, where men or other animals are congregated, and where ventilation is bad. They subside rapidly in still air by gravitation. Very few exist in mountain or sea air compared with the number found in the air of plains and of towns. Pathogenic bacteria may at times be transported from place to place by the air and disease may be thus spread.

---

* *Vide* Tyndall "On Floating Matter in the Air."

† Report of Special Committee of Royal Society, 1888.

‡ A recent calculation goes to show that a man may take more bacteria into his stomach in drinking ¼ litre of milk than he is likely to inspire into his lungs during a lifetime of 70 years.

Such organisms are drawn into the lungs with the inspired air, and thus the specific organisms of some diseases may enter the body ; or they may be arrested in the nose or throat and be swallowed. The rapid occurrence of fermentation or putrefaction (due to the development of microbes) in organic substances exposed to the air, and the growth of moulds (fungi) on such substances evidence the omnipresence of spores of these organisms in ordinary air.

Flying insects may act as carriers of disease. Contagious ophthalmia, anthrax, small-pox, cholera and typhoid have all on occasions been attributed to this agency.

Effects of Impure Air.

Diseases which are communicable through air are capable of being so communicated at very various distances, and some infections are transmitted much more readily than others ; it appears as though many disease germs were incapable of living long in pure air and that the term of their vitality in air were limited for each disease. It is probable, however, that under favourable circumstances the spores of some of these organisms may retain their vitality in air for a great length of time. Infections which are readily transmissible through air are those of the eruptive fevers (small-pox, measles, dengue, &c.), mumps, relapsing fever and whooping-cough. Those of cholera and enteric fever are less readily conveyed by air.

It is not often easy to ascertain the hurtful impurity in unwholesome air, for such air generally contains many kinds of impurity mingled. Thus air polluted by effluvia of decomposing animal matter often causes nausea or vomiting, loss of appetite, fever, with diarrhœa, and sometimes dysentery ; but it is not generally certain whether these effects are due to chemically poisonous gases evolved or to certain microbes contained in the air, though the balance of opinion and of evidence is in favour of the latter cause.

Impurities added to air by respiration.

	Inspired Air. Vols. per cent.	Expired Air. Vols. per cent.
Oxygen	20·96	16·40
Nitrogen	79·0	79·19
Carbon dioxide	·04	4·41
Aqueous vapour	Variable.	Saturated.
Organic matter	*Nil.*	Considerable quantity.

Air therefore loses during respiration about 4 volumes per cent. of oxygen and has added to it about 4 volumes per cent. of carbon dioxide, aqueous vapour and organic matter.

It has been calculated from a number of observations that an average adult man breathes 18 times a minute when at rest and expires 22 cubic inches each time or 330 cubic feet in 24 hours. Assuming that the expired air contains 4·4 per cent. carbon dioxide he evolves $\frac{330 \times 4{\cdot}4}{100} = 14{\cdot}25$ cubic feet of carbon dioxide in 24 hours or 0·6 cubic foot in one hour. The quantity evolved depends on the body weight: small men and women evolve less than big men, but children, weight for weight, evolve twice as much as adults. Exercise also largely increases the output. The above is the standard usually adopted for a mixed community. Little is known about the *organic matter* in expired air except that it is nitrogenous and quickly putrefies. It can be noticed by the smell when the carbon dioxide in the air of a room has been raised by respiration to ·08 per cent.

The discomfort produced by an overcrowded and ill-ventilated room is probably chiefly due to excessive temperature, increased humidity and unpleasant odours. The harmful effect of breathing vitiated air is more probably due to excess of carbon dioxide and want of oxygen than to poisonous organic matter. The immediate effect of breathing air rendered foul in this way is headache, sickness and loss of appetite: if it is habitually breathed general deterioration of health and increased liability to disease, especially to phthisis, are engendered.

PURIFICATION OF AIR—VENTILATION—COOLING.

It is manifestly of the greatest importance that breathing air should be as pure as possible. The great means for securing its purity is by constant removal and dispersion of impurities, to facilitate their destruction by oxidation or otherwise, and, at the same time, to provide a constant supply of fresh unpolluted air. This is the object of ventilation.

Subsidiary means are sometimes resorted to for the sake of destroying or getting rid of certain impurities : thus roads are watered to prevent dust in towns, wet grinding has been largely substituted for dry grinding in factories, smoke consuming furnaces are used to destroy smoke and noxious gases, the latter are sometimes condensed or dispersed high in the air by means of lofty chimneys, disease contagia are destroyed by chemical means or by heat; but ventilation is practically the sole means of purification for ordinary purposes of the air of dwelling houses.

Cleanliness is an important aid to ventilation in preserving the purity of air in houses. Microbes are comparatively few in the air of clean and of new rooms, while they abound in that of dirty and old rooms.*

In regard to ventilation we have to consider—firstly, the standard of purity which it is necessary to maintain in dwelling-rooms, and secondly, the means by which that standard may be maintained.

It is obvious that the air of inhabited places cannot be as pure as the external air ; but it is assumed,† and indeed it has been ascertained by observation ‡ that the sense of smell is generally a safe guide as to the purity of such air, and that if it does not differ perceptibly from the outside air the amount of impurity is not sufficient to influence the health of the inhabitants. Organic matter and fetid gases are the substances which affect the sense of smell, but carbon dioxide is generally taken as an indication of the amount of contamination of the air of inhabited places, because the quantity of this gas in air is easily determined by chemical tests.

Air as we have seen normally contains ·04 per cent. of carbon dioxide. The maximum amount allowed to be added to this by respiration is empirically fixed at ·02 per cent. carbon dioxide. Adding the two we get ·06 per cent., and it is the object in ventilation to keep the carbon dioxide down to this level.

---

* Carnelley : *Air of dwellings and schools and its relation to disease. Brit. Assoc.* 1886.

† Parkes and de Chaumont.

‡ G. Wilson's *Hand-book of Hygiene,* 6th edition. Air containing less than 0·08 per cent. CO_2 was found to have no appreciable injurious effect.

To find the quantity of air required by each person per hour, divide the amount of carbon dioxide exhaled by one person per hour (0·6 cubic foot) by the limit of admissible impurity stated in cubic feet (·02 per cent. = ·0002 in 1 cubic foot).

The result is $\frac{0\cdot6}{\cdot0002} = 3{,}000$ cubic feet which is the amount of fresh air required per head of a mixed assembly in order that the impurities added by respiration may not rise above the limit fixed.

A man doing hard work might exhale 2 cubic feet of carbon dioxide per hour instead of 0·6. In this case he would require $\frac{2\cdot0}{\cdot0002} = 10{,}000$ cubic feet of fresh air per hour.

Experiments show that more fresh air is required among the sick than among the healthy. Therefore not less than 4,000 cubic feet per head should be supplied in hospitals. It is a good rule to treat all sick persons as much in the open air as possible. Nothing is more likely to retard recovery or even to cause death than to confine a sick man to the smallest, darkest and, therefore, dirtiest room in a house. It is usual in Madras amongst the untaught multitude to thrust any one who falls sick into a room which has no window and, consequently, no ventilation to speak of, and, if the disease be an infectious one, all who enter are obliged to breathe the concentrated exhalations from his lungs and skin, and not unfrequently, from his excreta also, and thereby run much greater risks than would be the case in a well ventilated apartment.

It is an important requisite of good ventilation that the quantity of air required should be supplied without any very perceptible draught; for this purpose considerable cubic space is needed. It has been found in practice that the air of a room cannot be changed oftener than from three to four times in an hour without creating much draught. The best results in the practical ventilation of public buildings (schools) have been obtained with an air space of 1,000 cubic feet per head; a larger space appears to encourage stagnation of air.*

---

* Carnelley.

A large space is also useful, because, in case of temporary failure of wind or other means of ventilation, it affords a reserve of air and becomes vitiated less rapidly than a small space.

Large rooms are more easily ventilated than small rooms,* consequently in small rooms more numerous ventilating apertures and a larger cubic space per head should, if possible, be allowed.

A greater height than 12 or 14 feet is not generally found useful for the purposes of ventilation, and it is a good general rule that the superficial space (floor area) ought, in square measurement, to be not less than one-twelfth of the cubic space, in cube measurement.† Height is however of great service in keeping rooms cool in hot countries when the roof is strongly heated by the sun. Large superficial space is very useful in isolating individuals, allowing the rapid diffusion of the exhalations from their lungs and skin. In hospitals it is obviously of particular advantage. We have seen that efficient ventilation cannot be provided without draught in a room affording less than 500 cubic feet per head of space, which must, therefore, be regarded as in all cases the smallest amount of cubic space which is compatible with purity of air in a dwelling-room. One-twelfth of 500 is 41·7, and, in round numbers, therefore 40 square feet per head must be regarded as the smallest superficial space allowable. 100 square feet is a good allowance, and less than this should not be permitted in hospitals.

The smallest effective size of ventilating openings is the next point to be considered. The size of the inlet openings should be at least 36 square inches (6 × 6 inches) per head, and the outlet should be as large. This will allow 3,000 cubic feet per head per hour to enter and leave, supposing the air to flow through the openings at a rate of nearly 3½ feet per second, at which rate its motion is only slightly perceptible. It is impossible to obtain this constant rate of flow, except when artificial means of ventilation are employed; but under ordinary circumstances of climate in Southern India, when it is cold enough to have doors and windows closed, this minimum rate of ventilation will be secured by properly constructed apertures of the dimensions stated; and, if doors and windows are closed to exclude hot air in the day time, larger openings covered with wet grass mats should be provided.

---

* Found so experimentally by G. Wilson.

† deChaumont.

It is necessary for good ventilation that the pure air which enters should be well distributed. If there be few openings and the air enters at considerable speed, most of it may pass in a stream from one opening to another without spreading throughout the room. To prevent this many openings for ventilation are generally required in large rooms, or the incoming air may be directed in such a way that it shall spread. To effect this purpose, a simple contrivance is to direct the entering air obliquely upwards by louvres or an inclined board at the ingress. Another plan is to allow air to pass in through vertical tubes (Tobin's tubes), 4 feet or more high, fixed in the corners or along the walls of the room. Direction upwards of the incoming current of air, besides serving to disperse it, also protects the inmates from draughts.

The difference in temperature of the air within a building, and of that outside, is an important factor in ventilation. In cold climates the air inside is nearly always warmer than the outer air; and as the air within expands with heat it becomes specifically lighter and ascends, being replaced by colder air which passes inwards most rapidly by the lowest openings in the building. The greater the difference in temperature inside and outside the building, and the higher the building, the more rapid is the ascending current. For this reason, in cold climates, it is generally practicable to provide some openings which serve constantly for the ingress, and others which serve constantly for the egress of air.

In hot climates, however, the case is different, the outside air being sometimes colder and sometimes warmer than that inside, while sometimes the outside and inside temperature are equal. Thus upward, downward or no currents may be produced by temperature, and as the difference of temperature is never very great the currents from this cause are never strong. We have then usually in India to depend upon the wind for natural ventilation, and it is manifest that unless revolving cowls or artificial ventilation be resorted to, the same openings must serve sometimes for ingress and sometimes for egress of air. The most simple and direct methods of ventilation are therefore the best; and tubes, shafts, and valves should, as a rule, be dispensed with. In single-storied buildings, with low roofs, ridge-ventilation may be all that is required. In higher buildings ventilators may be placed in doors or windows at a height of 6 or 7 feet, or separate ventilators may be placed in the walls. Direct ventilation at the ground level through the walls is generally to be deprecated, as foul air is more likely to be found near the ground than higher. In the huts of the poor, and even in the houses of the wealthy, there is often an insufficiency of windows for good ventilation even when they are open. Where this is found to be the case, ventilators can, as a rule, be inserted at a very small cost. Tiled roofs, even when no ridge-ventilation is provided, generally afford a pretty free passage to air.

When, as occasionally happens, the wind fails entirely, and there is no difference of temperature outside and in to cause any movement of air, natural ventilation is impossible, and the air can be but slowly purified by the diffusion of gaseous and the subsidence of suspended impurities. In such circumstances doors and windows should be fully opened and people should, if possible, remain in the open air. The creation of movement by artificial means, as fans and punkahs, is particularly valuable under such circumstances.

Ventilation by shafts with revolving or fixed tops of various kinds is only efficient so long as the wind is pretty strong, that is when they are least wanted; but when the wind fails they cease to act as intended, and are less useful than ordinary direct openings. Such contrivances are therefore, as a rule, to be avoided for house ventilation. The proper ventilation of houses in Indian bazaars is often still further obstructed by the narrowness of the streets, and the available width is sometimes even further reduced by tatty structures which project over the roadway. The air in such places is always more or less stagnant and evil smelling, being undisturbed by the perflation of the wind, unless the latter be very high.

It should not be forgotten that cattle, goats and horses require as much as or more fresh air than human beings in proportion to their size, and that if they be confined in closed rooms and sheds where there is not sufficient cubic space, they suffer in health equally with human beings. Cattle should never, when it can be avoided, be stalled in one of the rooms of a house, as is not unfrequently done, or even in a verandah. Private cattle sheds should be open on three sides to the air and should be situated well away from the house in an open yard. In crowded towns private cattle yards are not to be encouraged; it is far better for the local authority to establish a public cattle yard where the animals can be kept under sanitary conditions and to lease out stalls to private owners.

An important point in connection with the ventilation of houses is the provision of apertures for the escape of smoke in cook rooms and for the escape of smoke and vitiated air arising from wood and charcoal fires in sleeping rooms. Charcoal in particular during its combustion forms a quantity of a poisonous gas called carbon monoxide; 1 per cent. of which in the air is rapidly fatal to human beings, while 0·1 per-cent. gives rise to serious symptoms. Numbers of persons annually meet their death by going to sleep in an unventilated room in which a charcoal fire has been lit for warmth.

It is generally found to be the case that the inhabitants of leaf and mat huts, which allow the free passage of air at all times, enjoy better health, even though they may be living in extreme poverty, than those who occupy more solid, but less well ventilated structures.

Artificial ventilation may be carried out by (1) the extraction of foul air, pure air flowing in to take its place, and (2) the propulsion of pure air into the building, the foul air being thus forced out. Fan-wheels or pumps worked by steam or water power, or fires to heat the air in a high extraction chimney, are the means most frequently employed on the large scale for artificial ventilation of mines and large buildings, and they need only be mentioned here. Punkahs and thermantidotes must be more fully noticed.

Punkahs have a more important ventilating action than is generally supposed. They not only cause the rapid removal and dilution of expired air and air tainted by emanations from the skin, but each swing acts like the stroke of a piston in a box and forces air out of the openings at one side of a room, while fresh air enters by the openings at the other side owing to the slight rarefaction produced.* This ventilating action is greatest and most useful when the air is stagnant. The cooling effect of a punkah is due to its causing a rapid change of air in contact with the skin, thus favouring evaporation of moisture from the skin, and also the abstraction of heat so long as the air is colder than the skin.

Thermantidotes are fan-wheels, usually driven by hand, used for propelling air into a room or house, the air being cooled by passage through a wet mat made of kus-kus or other grass. They are of little use as cooling agents in damp climates, when the air is already nearly saturated; but in dry climates the air of houses may readily be cooled by them to the extent of 20° F. or even more.

---

* This effect of the punkah must be largely modified by the size of the room and the energy with which the strokes are made.

The evaporation of water is a powerful means for cooling air. A quantity of water in evaporating absorbs as much heat as would raise four-and-a-half times the quantity from freezing to boiling point. The evaporation of 1 gallon of water will reduce 26,000 cubic feet of air from 100° to 80° F. The effect of cooling and moistening air to a great extent by means of wind, or air from a thermantidote, flowing through wet mats is prejudicial to health on account of the sudden change, and perhaps sometimes owing to the use of bad water. If such means be resorted to, care should be taken that the water employed be of good quality, and it is a wise precaution to add a little potassium permanganate to it.

Wet mats besides cooling the air and increasing its moisture, act as filters, and remove a large proportion of the suspended impurities which it may contain. A similar, though lesser, effect is sometimes obtained by placing trays of water in ventilating openings, the incoming air being caused to impinge upon the surface of the water. The cleanliness of these trays and of the water requires frequent attention. In cold climates when the air has to be warmed, it is found more effectual to heat large quantities of air to a moderate degree (by means of large radiating surfaces, such as a *gilled* stoves and pipes) than to heat small quantities more intensely. The same principle should be adopted in cooling the air: large surfaces of moderate cooling power being preferable to smaller ones of greater cooling power; for instance, large moderately damp mats are generally preferable to small well-wetted thermantidotes. More equable cooling is thus effected and draughts of very cold air are avoided.

Examination of Air and Ventilation.

The complete chemical, microscopic, and biological examinations of air are conducted on the same principles as similar examinations of water; but these, as well as exact measurements for artificial ventilation, must be left to skilled experts. The following easy scheme will, however, be found all that is generally needful and practicable:—

(1) Inspection of premises from outside to seek any possible cause of contamination of air entering a building such as accumulations of decaying vegetable or animal

matter, foul drains or latrines, slops thrown on ground, etc., in the vicinity of the doors, windows and other ventilating openings, or impurities lodged in the ventilating openings themselves.

(2) Inspection of interior of building to seek causes of contamination from within, such as dirt of floors and walls, accumulations of rubbish or dirty clothes, foul drains, sinks, bath-rooms, latrines, etc.

Local inspection is as necessary in the case of air-supply as in that of water-supply: in both cases dangerous impurities may otherwise escape detection, and in both cases the probability or the possibility of contamination must be guarded against.

(3) Examination of the sufficiency of ventilation of rooms under ordinary, or still better under *minimum*, conditions; for example, bed rooms should be examined early in the morning after they have been occupied by the full number of inmates during the night, and in their usual condition of ventilation, before such doors and windows as are closed at night have been thrown open. For this examination the two following ready tests may be employed:—

Smell Test.—The Inspector, after remaining for some time in pure open air, should rapidly enter the house or room and notice the odour if any. If the air in the room does not differ sensibly from the outside air, the ventilation may be regarded as perfect. If otherwise, three degrees of impurity * may be discriminated: (1) close, (2) close and unpleasant, (3) very close and foul.

Lime-water Test.—Lime-water is made by shaking a quantity of fresh burnt lime with water in a stoppered bottle, the lime is allowed to subside, and the clear water is drawn off for use as required; it must be kept in a well stoppered bottle. A clean dry bottle, preferably wide-mouthed, of nine ounces capacity, is filled with the air to be examined by pumping in the air with a small bellows or syringe.† Half an ounce of lime water, carefully measured, is then poured into the bottle, which is to be stoppered or corked with a clean cork (protected with wax if it does not fit very tightly) and set aside after being well shaken. After the lapse of six hours the lime-water in the bottle should still be quite clear when shaken up. If turbid, it denotes that more than 0·07 per cent. of carbon dioxide was present in the air examined.

---

* deChaumont.

† Or the ready method may be suggested of stuffing a clean bit of cloth several times into the bottle and withdrawing it.

An eight-ounce bottle will usually be more easily obtainable, and may be used for this test with half a drachm less ($3\frac{1}{2}$ drachms instead of half an ounce) of lime-water.*

(4) *Measurement of Superficial Space.*—The floor area or superficies of a room is, for an ordinary rectangular room, its length multiplied by its breadth. If the room is irregular in shape, it can be measured in segments, and the areas of the different segments be added together. If the walls form straight lines the floor can always be divided into triangles, whatever the shape of the room. The area of a triangle is height × $\frac{1}{2}$ base. If the walls are curved the following data may be useful. Area of circle $= D^2 \times 0{\cdot}7854$ ($D =$ diameter). Area of ellipse $= D \times d \times 0{\cdot}7854$. ($D =$ long and $d =$ short diameter.) Area of segment of circle $= \frac{2\,hc}{3} + \frac{h^3}{2\,c}$ ($h =$ height, $c =$ chord). The superficial space of a room having been measured is divided by the number of occupants in order to obtain superficial space per head.

(5) *Measurement of Cubic Space.*—The floor area multiplied by the height of the room gives its cubic space or contents when the ceiling is flat. The following data will enable the contents of gabled or arched roofs to be calculated: contents of pyramid or cone = area of base × $\frac{1}{3}$ height; contents of dome = area of base × $\frac{2}{3}$ height. The cubic dimensions of projections, pillars, and large pieces of furniture should be measured separately and be deducted from the contents of the room. The contents thus corrected divided by the number of occupants gives the cubic air space per head.

(6) *Inlets, Outlets, and Distribution of Air.*—In ordinary natural ventilation the same opening will serve sometimes for ingress and sometimes for egress of air, according to variations of wind and temperature. The points to be noted are that the openings are sufficiently large, sufficiently numerous, and placed at sufficient intervals to ensure not only the entrance, but the equable distribution of a proper quantity of air, it being remembered that large rooms and those containing least obstruction, such as

---

* Vide *Air and Rain*, by Dr. Angus Smith.

furniture, are more easily ventilated than small rooms crowded with furniture and require proportionately fewer openings. The distribution of the incoming air is usually tested by means of the smoke evolved from a smouldering rag held close to the apertures through which the air is entering. It may thus be observed whether the air is evenly distributed or passes in a stream from one aperture to another. Instead of the smoke-test a smell-test may be employed, any strongly smelling substance being placed at the apertures through which air is entering, and the distribution of the smell in different parts of the room being observed. The deflection of the flame of a candle or match held at any aperture will show whether air is flowing in or out through it, even when the current is too weak to be felt.

(7) *Arrangements for cooling, warming, or moistening the air* should be examined especially with reference to the purity and sufficiency of the air supplied. Two methods of cooling or keeping cool the air of houses are commonly practised : (1) cooling by evaporation of water, (2) shutting doors and windows to exclude radiant heat and hot air during the hottest part of the day. Cooling, dependant upon methods of construction of buildings may also be examined under this head; details will be found in the chapter on houses.

CHAPTER V

REMOVAL OF WASTE.

The constituents of the waste of human habitations are (1) latrine waste, comprising excrement, urine, and washing water; (2) kitchen waste, consisting of refuse portions of vegetable and animal food, washings of cooking vessels, and ashes; (3) house waste proper, general house sweepings and bath water; (4) stable waste, excreta of domestic animals and litter. In addition to these substances, towns have to remove factory waste and street sweepings. The refuse of slaughter-houses may be treated as latrine waste. All these substances have to be speedily removed and suitably disposed of in order to preserve the purity of soil and air in and about dwellings and to prevent contamination of water. Such removal and disposal is one of the most important duties of executive sanitary authorities and one upon which the health of towns especially depends.

Diarrhœa, febrile attacks, general ill-health and sore-throat are the most common and general results of exposure to emanations from foul sewers or accumulations of decaying organic matter.* Such emanations also undoubtedly increase the liability to specific diseases, such as cholera and enteric fever.

Liquid waste of all kinds, whether including urine and ordure or not, is termed *sewage*, and the channels by which it is removed are *sewers*. Drains, of which the primary use is to carry off water from the surface or from the depth of the ground are occasionally used also for conveying sewage and thus serve a double purpose.

The *separate system* of drainage and sewerage provides for the removal of sewage in small well-made sewers, while storm water and drainage generally is carried off by large drains which need not be so carefully nor expensively constructed. The advantages of this system are that the sewers are very small and proportionately inexpensive; they are not so liable to be blocked because the quantity of sewage is tolerably constant and silt conveyed by storm water is excluded; the sewage is more highly concentrated and therefore more valuable as manure; while the drains need not be watertight and will consequently be more efficient for subsoil drainage.* The *combined system* of drainage and sewerage provides for the removal of drainage and sewage together in large sewer-drains which are expensive to build and maintain, while their large size is a disadvantage except during rain; they are likely to become blocked by deposits of mud and sand, and unless leaky they are of little or no use as sub-soil drains.

---

* Albuminuria appears to result occasionally—*Vide* cases reported by Dr. George Johnson in the British Medical Journal of 1888.

The waste matter which has to be disposed of may be conveniently considered under the headings of street sweepings, excreta and sewage.

We may compare a town with the human body. Each produces a quantity of waste matter daily which has to be got rid of or health declines. The carts which remove the solid refuse from a town play the part of the bowels of the human body. Failure to remove town refuse has as bad an effect on the health of the community as chronic constipation has on the health of the man. Drains and sewers match the kidneys and urinary passages. An obstructed drain leads to similar symptoms in the community as retention of urine in the man, and a leaky drain poisons the sub-soil just as extravasated urine poisons the tissues of the man.

In olden times the remedy adopted to avoid self poisoning by the accumulation of excreta and organic refuse round dwellings was migration. Gregarious animals also from time to time migrate for a similar reason. Our manner of living is now-a-days too complex to permit the removal of residences from polluted areas, so we have to remove the refuse to prevent pollution.

STREET SWEEPINGS.

The composition of house refuse and street sweepings differs in different countries and towns: it always contains much putrescible matter which becomes offensive in a few hours when the temperature is high. It should, therefore, not be heaped up in a yard adjoining the house for days together, nor be allowed to lie about in the streets.

---

* This important advantage, especially in malarious places is too commonly lost sight of.

Whether *it* be in a town or in a populous village the ideal system is for each householder to collect his refuse in a moveable metal receptacle which can be emptied twice daily by a public service of carts. If the women of the household simply throw their refuse outside into the street it is blown about by the wind and sorted by animals, and endless trouble is given in sweeping it up, not to mention the danger of possibly infected matter being spread about. Public dust-bins are necessary in busy parts, but they cannot altogether take the place of private ones, and there is frequently a difficulty in finding a suitable site for them.

The pattern does not matter; all that is required is that a dust-bin should be of non-absorbent material and so constructed that it can be easily and completely cleaned. Where there are no private dust-bins one public one to about 110 people will suffice.

Rubbish carts should be covered in to prevent their contents being blown about as they traverse the streets. Ordinarily one rubbish cart carrying $\frac{1}{2}$ ton and working two trips daily will serve 1,200 people. In towns 1,000 persons will afford from $\frac{1}{2}$—1 ton of rubbish per diem, or from 25—40 cubic feet.

Disposal of Rubbish.

After collection there are two ways open for disposal (1) Dumping, (2) Incineration. Theoretically the proper way to get rid of rubbish is to dig it into ground under cultivation where it becomes disintegrated and enriches the soil. Practically, however, difficulties often prevent this. Dumping, or filling up low ground and reclaiming useless land, is sanitarily unobjectionable, provided that the place is one far removed from habitations and pollution of the air and soil for the time being do not much matter; but difficulties often arise on account of the expense of transport. On no account should tanks, old wells, or low ground near inhabited areas, or where there is any danger of polluting a water-supply, be filled up with rubbish. To prevent smell from a rubbish heap and the development of too many flies the sweepings should at once be covered over with a layer of earth or silt 6 inches deep. An old rubbish heap must not be built over until the organic matter has been completely destroyed. This may take 5, 10, or even 20 years according to circumstances. The only sure test is to dig a hole and examine the condition of the soil down to the bottom of the deposit.

Nothing will grow on fresh rubbish heaps, and trees which are growing close to one may even be killed. After six months grass and shallow rooted plants may profitably be put down. Indian rubbish contains nothing of value. Crows and dogs and buffaloes devour everything eatable before it leaves the streets, and the people never throw away anything that can be sold. In England rubbish is sorted; tins and old iron are removed for melting down, paper and rags for making into paper, bones for manure, and so on. Enough wood, coke and coal dust are found mixed with it not only to enable it to burn readily, but to supply enough heat for running machinery.

In India the quality of the rubbish is often such that it will not even burn itself without added fuel. In spite of this fact in the larger towns the expense of transport to a distance and the lack of suitable dumping grounds have rendered it necessary to resort partially at any rate to incineration.

A description of *rubbish destructors* or *incinerators* would be out of place in this manual: it need only be remarked that if carefully constructed and managed, they can be situated in the heart of a town without sanitary offence, that the rubbish that passes through them is rendered perfectly innocuous and that the resulting ashes can be applied to a variety of useful purposes. Small incinerators of the beehive and other patterns which have no provision for inducing a good draught are useless except for burning the refuse in the compounds of hospitals, jails, and other institutions. They might, however, serve a useful purpose in small villages of under 1,000 inhabitants, if the people could be persuaded to keep them going.

EXCRETA.

QUANTITY. *Solid.*—Meat eaters, adults about 4 ounces daily; vegetable eaters, adults 8—16 ounces daily; women and children, less.

For a mixed Indian community, 8 ounces per head per diem is not too much to base a calculation upon.

Liquid.—From 35—45 fluid ounces of urine daily. When fresh fæces are usually acid; on decomposing they become alkaline from the formation of ammonia. If kept dry and free from urine or water fæcal matter decomposes slowly, but when mixed with urine both decompose rapidly. The highly nitrogenous excreta of carnivora are more offensive than the slightly nitrogenous excreta of herbivora.

It is a significant fact that many species of the former, *e.g.*, cats, tigers, cover their dejecta with earth, whereas the latter never do so.

The term " conservancy " should strictly speaking be applied only to those systems in which excreta are removed by hand, *e.g.*, pail, dry earth, and midden or pit systems. Most sanitarians are now agreed in looking on these as wrong in principle and only make-shifts. Our ideal should be to get all excreta as far away from habitations as possible with the utmost expedition, and this is best attained by water carriage. A great argument in favour of the water carriage system in India is that when it is in operation the populace is less at the mercy of that very intractable community who are variously entitled bhangis, halalkhors, toties, and mehters, and who can be influenced by nothing but the rod, which it is not legal to apply. As far as towns are concerned every house holder who can afford one should have a latrine on his premises, and the Municipality should provide a sufficiency of public latrines for the use of the dwellers in bastis, parcheries, hutting grounds and the like. Until this is done persons who defæcate in byeways, ditches, and on waste land, cannot with justice be prosecuted.

All systems which involve the retention of fæcal matter on the premises, whether in towns or in villages, must be condemned without reservation, whether the excreta be dropped into deep pits or mixed with earth in a hole. The soil is polluted and the wells become so contaminated that the water may even be too brackish to drink, and the odour in the houses is sometimes overpowering to one who is not accustomed to it.

By the *dry earth system* is understood the separation of the urine and fæcal matter and the admixture of earth with the latter, the urine being separately removed, or the addition of a sufficiency of dry earth to both urine and fæces to soak up all moisture and prevent any odour. The system aims partly at keeping the matter dry and retarding putrefaction till it can be removed, which is equally well performed by ashes or powdered charcoal, and partly at starting the nitrification of the organic matter at once by mixing it with an earth rich in nitrifying organisms. On a small scale when managed by people who understand it the system works exceedingly well; the mixture is carted away and the fæces rapidly nitrify, and then the same earth can be used again many times. On a large scale difficulties of transport and supply of dry earth render the system inapplicable. There is nothing however in dry earth to destroy pathogenic organisms, and it has been pointed out that in towns which used this system the number of attacks with typhoid fever was greater than in others which had water carriage.

In towns where dry earth is not used the excreta have to be collected directly from private and public latrines.

The patterns of *house latrines* are numerous, and cannot be described here: the essential points being a smooth and impervious flooring which can be readily cleaned, and some form of moveable receptacle to catch the excreta.

Many different forms of *public latrines* are in use which vary from a simple mud walled enclosure to a highly complex structure of iron and pottery. A mere enclosure has of course nothing to recommend it, but of the other patterns, no one can be said to be pre-eminently the best. Far more depends on the innate ideas of decency of the persons who use the latrine than on the many devices introduced with the object of securing a particular position during the act of defæcation. However well thought out a latrine may be, it will be misused; therefore the simpler it is the better, and trouble expended in securing efficient scavengering is better repaid; in fact that is the only way nuisance can be avoided in a much frequented latrine.

The next point is how in the absence of a sewerage system can excreta collected in carts from public and private latrines best be disposed of. The object in view should be to utilise as far as possible the stuff as manure. Incineration which is practised in some places on a small scale is both expensive and wasteful; it should be confined to hospitals where it is necessary to completely destroy the excreta in the case of communicable diseases such as typhoid and cholera.

In other places the excreta are mixed with ashes obtained by burning rubbish and turned into "*poudrette*" which in Poona commands a ready sale as manure. The tastes of cultivators however vary in different parts, and in the Madras Presidency poudrette is not fancied. Cultivators will rarely take fresh night soil for manure; they prefer it to be matured for several months.

The most widely adopted method is "*trenching*," and this if properly carried on gives eminently satisfactory results. When night soil or any other organic matter is put below the surface of the ground putrefaction with the evolution of foul smelling gases is arrested, and a class of bacteria, which are found in the soil and are known as nitrifying bacteria, grow in it and change the complex nitrogenous organic matter into simple nitrates and turn it into fit food for plants. This process is most active in the upper layers of the soil where oxygen is most plentiful; the deeper the burial the fewer bacteria, and the slower the process of nitrification. Trenches, therefore, for night soil should not be more than one foot deep and not more than 9 inches depth of night soil should be put in them. The ground must be of a light porous nature so that moisture is rapidly absorbed, a clay soil being most unsatisfactory. Care must be taken in selecting the site so that there is no possibility of contaminating a water-supply. It often happens that a sufficient area of suitable ground is not available within a reasonable distance and the trenches are made deeper and more night soil is buried in each. Retardation of the process is the result.

A plot of land one acre in extent will suffice for the excreta of 4,000 persons for 315 days if trenches 20 × 3 × 1 feet are used, leaving 3 feet between each. Under favourable conditions complete disintegration of the contents of the first trenches will have taken place at the expiry of this time and the land can be used over again, the second lot of trenches being cut at right angles to the first. If sufficient land be available it is a good thing to thoroughly plough up and grow a crop on the trenched area before using it again. The disadvantages of the system are chiefly apparent in connection with large towns where difficulty is found in acquiring suitable sites within easy reach. During the rainy season also many difficulties arise. On the whole, therefore, trenching is not usually a system to be recommended for adoption by large towns which can afford a water carriage system.

The Water Carriage System.

Much has been heard of the inadvisability of thrusting innovations of western origin on an eastern community whose customs and prejudices are not in harmony with them, but there is no reason why, when due modifications have been introduced, an up to date system of sewers should not work as successfully in India as in Europe and carry excreta as well as dirty water. Even though custom and poverty forbid the establishment of water closets in native houses the collection of excreta in the usual way in carts and pails may go on, and, instead of having to be transported through miles of streets, their contents may be delivered at convenient stations and forced into the sewers under pressure as is now done in parts of Karachi and Bombay and will shortly be done in Madras. But it is in connection with public latrines that the water carriage system is of inestimable advantage. They cease when connected with sewers to be a continual source of offence to the neighbourhood and a nightmare to the conservancy department. The arrangement is simple, merely a cemented trough 1½—2 feet deep covered with stone seats with sufficient apertures between them. The fæces are removed from the trough at stated intervals by a flush from an automatic tipper and pass through an intercepting trap into the sewer. The seats should be partitioned off and the latrine light and airy. Respectable people who would not go near an ordinary latrine use this type willingly, as it is always clean and there is no smell. Moreover in Madras at least trough latrines are not misused and fouled in the way in which other patterns invariably are.

SEWAGE.

In towns, and villages too, the disposal of waste water is a serious problem. Naturally, the more abundant the public supply the more waste there is to be removed, and there is least water wasted in those towns which have no pipe water-supply. When every drop of water has to be fetched from a distance, or bought, or drawn up from a deep well, people are extremely careful of it. In a town which has street fountains a cooly will not hesitate to expend 20 gallons in sluicing his legs and will often omit to turn off the tap when he moves on, nor will the policeman standing by or any rate-payer think of repairing his error.

In the mofussil, and more particularly where each house stands in its own paramba as in Malabar, many householders should be able to dispose of their organic refuse by incineration and burial in accordance with the principles laid down above, not only without sanitary offence but with advantage to their gardens. Waste bath and cooking water is under these circumstances best dealt with by irrigating the garden plants, care being taken to prevent the formation of pools and small swamps anywhere. If there is too much water for surface irrigation it may be allowed to run along unjointed eathernware pipes laid not more than one foot below the surface. It is then rapidly purified by nitrification and does not render the surface damp. Care must be taken to avoid introducing quantities of foul water into the sub-soil some feet below the surface where the nitrifying organisms are few. It is easy to contaminate the sub-soil water and any well near in this way.

In towns where there are no gardens, it becomes necessary to have some system of drains to carry away the liquid waste of houses. Where drains do not exist, each house has to have an open "catch-pit" in front which is bound to be a nuisance, or else an underground "sink-pit". If the sides of these pits be pervious, the sub-soil is fouled to such an extent that the wells sometimes become too brackish to be used ; if impervious, difficulties are always arising in connection with the regular removal of their contents. Such systems have nothing to recommend them.

The next step in evolution is the *open side drain* which carries sewage and storm water. When these are not constructed in such a manner as to prevent soakage into the soil and with sufficient fall to carry away the sewage rapidly they are hardly an improvement on catch-pits and sink-pits. Even when made in cement with the approved oval section, extended experience, as in Madras, has shown that they work by no means satisfactorily. Their great advantage was supposed to be freedom from smell owing to the immediate dilution of any foul gas formed in the open air.

Really, they cause constant complaints by reason of the smell evolved, and space will not permit an enumeration of their other disadvantages.

Under-ground Sewers, though they have certain disadvantages such as leakage through faulty joints and cracked pipes, which all unknown may foul the sub-soil and contaminate the pipe water supply, possess advantages which far outweigh them. Not the least are the possibility of the water transport of excreta, and the direct connection with house drains which prevents much mud and detritus entering the sewer. When houses are not fitted with water closets it is quite unnecessary to insert intercepting traps in each house connection, a disconnection outside the house is sufficient to allow any sewer gas a free exit, and this may be ensured by the addition of a ventilating tube. In few places in India can it be safe to expect sewers to carry storm water as well. Owing to the structure of native houses the drainage from courtyards and roofs during heavy rain will find its way through the house drain into the sewers and augment the total volume of sewage considerably.

This cannot be helped and is perhaps no great disadvantage, but the ordinary surface washings of roadways and open ground generally should be otherwise provided for by storm water ditches leading to a convenient outfall. A working knowledge of gradients, pipe laying, construction of sewers, materials for pipes, forms of traps, water closets, ventilating shafts, manholes, inspection chambers, cleaning apparatus, &c., is essential for any one engaged in practical sanitary work, but descriptions of these things cannot find a place here.

Silt and deposits removed from silt traps, manholes, and sewers, should be at once removed to a suitable dumping ground. The practice of leaving such matter by the roadside for the water to evaporate to save cost of cartage is sanitarily incorrect. No sewer or drain should pass beneath a house or building where it is impossible to examine it in case of leakage. It must not be forgotten that decomposing sewage evolves combustible gases and that it is often dangerous to carry a naked light into a newly-opened manhole, old drain, or cesspool. Careless coolies are not unfrequently seriously injured by explosions under such circumstances. Either a Davy's lamp should be used or time given for the cavity to be thoroughly ventilated. The air in old drains and cess-pools may contain poisonous gases and persons entering them may lose consciousness or even die. In less concentration these gases give rise to vomiting, diarrhœa and prostration. Long exposure to air contaminated with emanations from sewers or cess-pools, though it may not cause definite disease, leads to a lowered vitality and, consequently, predisposes towards disease in general.

Disposal of Sewage.

Sewage collected in catch-pits must be daily removed in metal tank carts. The method of ladling it out in buckets leads to great offence and entails the spilling of a quantity on the roadway. It is far better, when it can be afforded, to pump it up into the cart through a hose let down into the liquid. The sewage is then best disposed of by irrigating a plot of land set apart for that purpose on which grass or vegetables are grown. Under no circumstances should untreated or crude sewage be discharged directly into the sea, a river, nullah, or tank. It must be remembered that the sewage is of high manurial value and that it is the duty of the local authority to make the sewage pay for the cost of its collection, and at the same time to enrich the community by improving the producing power of the land under cultivation.

Purification and Utilisation of Sewage.

Our object is so to treat sewage that the effluent or resulting liquid that flows away, if not all required for irrigation, may be safely discharged into any water course, and at the same time to endeavour to make the process pay for itself in the way of manurial value obtained. Two methods are adopted, sometimes separately, sometimes in combination, (1) Chemical, (2) Biological.

The chemical processes have for their object the precipitation of the solid constituents of the sewage. This is effected by the addition of lime, alum, protosulphate of iron, or some other chemical to the sewage in settling tanks.

The precipitate formed gradually sinks to the bottom and carries down with it the greater part of the suspended matter, and the clarified fluid is run off and further treated or discharged into the sea or a river as the case may be. The process has little to recommend it, partly on account of the expense and difficulty attending the removal and safe disposal of the precipitate or "sludge" from the bottom of the settling tank, and, partly, because the effluent is by no means pure but is still capable of putrefaction, and pathogenic organisms pass away with it unharmed.

The biological processes may be considered under three headings—

(*a*) *Broad irrigation or sewage farming.*—The sewage is distributed over the surface of a chosen plot of land which should be of a porous character, by a system of bunds and channels, the object in view being to obtain as abundant crops as possible consistently with due purification of the sewage. The action that takes place is (1) mechanical filtration by the soil, (2) nitrification of the organic matter by the nitrifying organisms in the soil, (3) absorption of the resulting products by the roots of the plants grown. The sewage must pass through the soil and not merely over it. Much of the liquid is evaporated and the rest soaks into the soil. It may be necessary to under-drain the farm to carry away the excess of liquid. If the area of land available is large enough to deal with the quantity of sewage applied to it, the result is very good and can be allowed to join the sub-soil water or drained into a water course without danger or risk of putrefaction. If too much sewage be applied the ground becomes sodden, purification does not occur, and the crops will not flourish. The only danger is the possibility of unpurified sewage passing directly into the sub-soil through cracks, and contaminating wells in the neighbourhood or even at a considerable distance, but this is only likely to occur in a sub-soil of chalk or clay and not in sand.

Harriali grass is the crop grown on sewage farms in Madras, but sugarcanes, plantains, vegetables, and even fruit trees, can be cultivated with equal success and profit, if care and trouble be taken. No harm results from eating vegetables manured in this way.

(*b*) *Intermittent downward filtration* is only employed when suitable land for sewage farming is not available. The object is to purify as large a quantity of sewage on as small an area of land as possible. Cultivation is carried on, but the produce is of secondary importance to the purification of the sewage. Porous beds of gravel and sand have to be laid down if the area is not of a sufficiently porous nature, and under-draining must be employed. The principle of the action is the same as in sewage farming. Some of the solid matter is first removed from the sewage by precipitation or sedimentation to prevent the pores of the filtering surface being blocked up, and the land is divided up into plots, each of which is irrigated, say, for 6 hours, and allowed to rest and aerate itself for 18 hours, while another is being used. This is to allow the nitrifying organisms time to do their work of purification. The effluent is clear and does not putrify and can be drained off into a river.

(*c*) *Biolysis* of sewage or solution by living organisms. Bacteria are divided into three groups--

(1) Those that require oxygen for their growth—aerobes.

(2) Those that cannot grow in the presence of oxygen—anaerobes.

(3) Those that will grow either in the presence or in the absence of oxygen.

All these groups contain bacteria which take a part in the purification of sewage; but in order to obtain the best results the sewage must be exposed to the action of the first two groups under the conditions most favourable to them. It is impossible here to attempt to describe the different arrangements that have been invented for the purpose of treating sewage by biolysis; the principles merely can be discussed. The sewage, after passing through a grit chamber to allow mineral matter to subside, runs into a tank, known as the "Septic Tank", large enough to hold 24 hours flow. Air and light may be excluded by a roof, but this is not absolutely necessary, for a thick scum usually forms on the surface of the liquid which serves the same end. It takes 24 hours to pass through the tank, and all this time it is being acted on by anaerobic organisms which feed on and dissolve the solid organic matter and give off large quantities of inflammable gases in the process. On leaving the septic tank the sewage has been partially purified. To prepare it for the action of the aerobic organisms, it must be mechanically mixed with air, and then run on to beds containing cinders, broken bricks, coarse gravel or some such material, the rough surfaces of which afford a resting place for the aerobic organisms which complete the process of purification by feeding on the nitrogenous matter, which has been rendered soluble by the anaerobes in the septic tank, and by breaking it up into non-inflammable gases and simple salts. The effluent or final product contains little or no organic matter, but a considerable quantity of mineral salts in solution, nitrates, chlorides, sulphates, phosphates, etc. By this means a non-putrescible effluent containing all the substances necessary for the support of vegetable life is obtained from the crude sewage, without the formation of immense quantities of sludge and without the expense of chemicals.

It can be run into a river directly, but it is far better to utilise it for irrigation having regard to its high manurial value. It is not yet finally decided whether pathogenic micro-organisms ever appear in such an effluent or not, so it is as well to be on the safe side and to treat the effluent as if it might contaminate drinking water.*

In some modifications of this process no septic tank is used, but the sewage passes first through an upward filtration bed, in which it is acted on by the anaerobic organisms, and then through the downward filtration beds which contain mainly aerobic organisms.

---

* The Sewage Commission sitting in England in 1902 held that this method cannot yet be relied on to remove pathogenic organisms. The effluent should therefore be further purified on land.

It is essential that the downward filtration beds should be allowed to rest empty for several hours to aerate themselves thoroughly before being filled again.

Biolysis is the cheapest, most satisfactory and safest way of dealing with sewage when suitable land is not available for broad irrigation, and the method has a wide application. In India it is being used for the purification of sewage mixed with excreta, of the waste liquor and washings from dye works, of ordinary sewage, and in connection with public latrines. It can be arranged to purify the sewage of a large town or of a single house standing by itself.

The provision of *urinals* in crowded public highways is part of the duty of the municipal council. When sewers are handy, and plenty of water for flushing, there is no difficulty in keeping them clean; but if the urine has to be collected in a tub it is almost impossible to avoid some nuisance. No filtration on the spot is generally successful, and the only remedy lies in frequent removal.

VILLAGE LATRINES.

The custom of the inhabitants of small villages to resort to the fields with their lotahs for ablution, is excellent in principle; but they should prefer cultivated fields instead of waste ground in order to save valuable manure and utilize the deodorant properties of tilled soil, and it would be an improvement to imitate the practice of the ancient Jews who buried their ordure. The banks of tanks, streams and canals near villages are almost invariably used as latrines, the water being convenient for ablution. Village authorities should be taught the danger of such pollution, its tendency to cause the spread of intestinal worms, dysentery, cholera, and some other diseases and they should be responsible for its prevention.

Latrines, however, cannot ordinarily be dispensed with, whether for public or for household use. In villages, decency, cleanliness, deodorization and utility would all be promoted by a simple plan of moveable latrines; shallow trenches 9 inches wide and 9 inches deep being dug every afternoon and surrounded with a moveable wall of matting, the old trenches being filled in and the latrine moved to fresh ground every day, or less frequently according to requirements. Persons using these trenches should squat across them with a foot on each side. If villagers could once be induced to adopt this plan they would probably appreciate its advantages and willingly retain it. Small latrines of this kind may also be advantageously used in private gardens when these are sufficiently large.

The want of small towns and villages is not the provision of public latrines so much as attention to the condition and cleansing of the private latrines which exist, or should exist, in connection with all houses. Sick people, children, gosha women, and all persons at night, must have some place on the premises where they can relieve the calls of nature. The pollution of soil and air which habitually goes on in the corners of courtyards set apart as latrines close to all ordinary dwellings, is as dangerous to health as it is disgusting to the senses.*

Covered Sewers and Sewer Drains.

The subject of sewage is unsavoury and distasteful; this is one reason for the tendency to put everything connected with it out of sight. The ignoring and hiding of filth have led to innumerable sanitary evils; disease and death too surely teach that it is a most foul and dangerous practice to conceal and store instead of removing and utilizing it. Cess-pools and large ash-pits are now condemned by all sound sanitarians, but the use of underground sewers cannot be avoided in crowded and level towns where there is not space nor sufficient inclination of the ground for open ones. The well-made underground sewer of the present day is, however, very different from the ill-constructed leaky, unventilated sewer of the past, which was often no better than a cess-pit. Certain points have now been recognized as essential for good sewerage; these are briefly firm foundations, proper gradients, correct size and shape, junctions in direction of flow, direct lines and wide curves, smooth surface, "imperviousness of material, free aeration, and facility of inspection at all points".

---

* Such foul places may be found attached to nearly every house, not only to the houses of the poor. Kanny Lall Dey (*Hindu Social Laws and Habits*, Calcutta, 1866) gave graphic descriptions of the rarely cleaned ash-pits, privies and cess-pools, with adjoining wells and dirty bathing-pools in houses of the wealthier classes. Such descriptions are still too frequently applicable.

Leakages in sewer-pipes may be detected by several methods of testing. The water test consists in completely blocking the lower part of the pipe and filling it with water from above; if the water does not sink, it shows that the pipe is water-tight. The smoke test consists in blowing smoke in at one end of the pipe; the smoke finds its way out through any leaks.

The smell test consists in pouring any strongly smelling liquid into the pipe; it may be smelt wherever there is a leak.*

Disposal of Dead Bodies.

The bodies of animals which are not used as food, or which have died from the effects of non-infectious disease, should be disposed of in the same manner as other organic refuse. The bodies of animals which have died from infectious diseases should be destroyed by burning or by burial in quicklime, in order that the microbes which are the causes of such diseases may be got rid of.

Human bodies are disposed of according to the dictates of custom, convenience, and religion. Cremation, burial, exposure (as by Parsis), and casting bodies into rivers, are the methods followed in India. Cremation, properly carried out, is quite unobjectionable; it is best performed in specially-made covered furnaces. Burial is also a good method if the graves be deep, far apart, and placed at a distance from any source of water or habitation. Quickly growing trees, such as casuarina, may with advantage be planted in burial grounds. Exposure of bodies and casting them into rivers are customs which are both offensive and dangerous, especially in populous places.

Attention is much required to prevent or correct some very prevalent malpractices with regard to cremation and burial. Both cremation and burial-grounds should be far from any dwelling or water-supply. Imperfect cremation is very objectionable, and a proper supply of fuel should always be provided. It would be best, in large villages and towns, always to employ furnaces. In the case of burial, shallow graves should not be permitted;* they ought to be fully 6 feet deep. A custom which is little better than that of throwing dead bodies into rivers is that of burying them in river-beds during the dry season. Tanks and wells in burial-grounds are very dangerous, as even if not habitually used for drinking, the water may be so used.

---

* In well jointed sewers leakages may occur from sinking of foundations or the growth of roots. Eassie states that the penetration of roots may be prevented by a coating of tar which causes them to turn away.

Dead bodies, especially those of persons who have died from infectious diseases, should not be kept long in houses, but should be cremated or buried as soon as possible. Those which are likely to spread infection or have become offensive should be completely wrapped up in a cloth saturated with some disinfectant † before removal.

Burial grounds should be kept under close supervision and interments should be made in regular lines leaving a clear two feet between the graves. If this is not insisted on graves will be scattered here and there all over the area, and it becomes impossible to say how much available space is left. Permission to open up old graves for the interment of other members of a family should be sparingly given.

---

* In Egypt the author has noticed a practice of burial above ground, a tomb being built up of mud and the body simply deposited in it. During the cholera epidemic of 1883, a well situated in a large over-crowded graveyard containing such tombs was largely used for drinking purposes, the water being reputed holy. Cholera and enteric fever were very fatal in this place.

† One part of corrosive sublimate in 1,000 of water is one of the best. A strong solution of zinc chloride or of carbolic acid may also be used for this purpose.

CHAPTER VI.

LOCAL CONDITIONS: SOIL, CLIMATE, AND METEOROLOGY.

I. Soil.

Constituents of Soil.

Soils consist of a great variety of mineral matters generally mixed near the surface, and sometimes to a great depth, with some vegetable and animal substances, and containing more or less air and water. Dense non-porous rocks, such as granite, quartz, and limestone, are the only constituents of soils which never contain organic matter, and only inappreciable quantities of air and water.

The soil may broadly be looked upon as consisting of three layers—

(1) The surface soil or humus, which is a mixture of mineral particles with disintegrating animal and vegetable remains. It varies in depth according to circumstances, being thickest in undisturbed forest land and non-existent in dry sandy deserts which are devoid of vegetation.

(2) The sub-soil, which is chiefly composed of the decomposed products of the rock stratum below.

(3) The underlying rocky strata.

The physical and chemical composition of the mineral matter which forms the bulk of the sub-soil and all the strata beneath influences greatly the dryness and porosity of the soil on the one hand and the purity of well and spring water on the other.

The organic matter contained in soil may be regarded in the same light as organic impurity in air and in water. It may be animal or vegetable, living or dead. The dead organic matter consists principally of decomposing remains of plants and of the dead bodies and excrements of animals, large and small. Dead organic substances may occur as fragments mixed with the inorganic particles of the soil, or as products of the decomposition of such substances, for instance, humic and ulmic acids, or as filmy incrustations upon the inorganic particles. Soils, such as sand, gravel, or disintegrated gneiss, which seem to be very free from organic matter, often contain a considerable quantity in the latter form. The author has noticed in such soils in the Deccan particles of quartz and other stone from which the organic incrustation could be peeled off almost like the skin of a peach,* and particles of sand so incrustated can be recognised under the microscope. The living organic matter in soil consists of burrowing animals, worms, larvæ, eggs (perhaps of parasites), ants and other insects, and microscopic animals of simpler structure, and, besides the larger vegetable organisms, of *fungi* and *bacteria,* which play a most important part in the economy of the world. Microbes exist principally in the surface soil. Damp porous soils, rich in decaying organic matter, are those in which they flourish most, and such soils are notoriously the most unhealthy. It is held by some authorities that the microbes which cause certain diseases breed and multiply in the soil, and there is good ground for this belief in several cases. Under the influence of microbic growth in the surface soil, organic matter becomes decomposed and oxidized. Nitrogenous organic matter yielding ammonia is oxidized to nitric acid. Large quantities of nitre (potassium nitrate) are hence found in the polluted soil of old towns, the potash being supplied by wood ashes and vegetable refuse; the extensive deposits of nitre which exist in many parts of India are believed to mark the sites of ancient centres of population.

Organic matter is generally found most abundantly in the surface soil; but sometimes it is deposited in the deeper layers; for instance, when a porous soil, such as sand or gravel, rests upon an impervious layer of clay or hard rock, a large amount of organic deposit may exist in the lowest portion of the porous soil, being matter carried down by the water which percolates through the soil.†

Air in Soil.

Air contained in soil is very impure as it is mixed with the gaseous products of decomposition of organic and inorganic constituents of the soil. The quantity of the ground air depends upon the looseness of the soil. It is rich in carbon dioxide, is moist, and contains organic matter. The actual composition differs in places and at different times in the same place; but, as a rule, the amount of oxygen diminishes and that of carbon dioxide increases with the depth. The oxygen is absorbed to oxidize organic matter, and carbon dioxide is one of the results. The percentage of nitrogen remains the same as in the atmospheric air. Workmen, who have descended deep unused wells, have sometimes died from want of oxygen before they could be rescued. It is important that such impure ground air should be prevented from rising within houses by rendering their basements impermeable. It is also important that the flow of air into and out of the soil should be limited as much as possible. Such a flow is promoted by (1) differences of temperature between the soil and the upper air; if the soil be warmer there will be exhalation from it and *vice versâ*, trees and herbage are useful in preserving equable temperature of the ground; (2) differences in level of sub-soil water; water rising in or permeating the soil must displace air; (3) permeability of the surface; paving or other means which render the surface more or less impermeable, even herbage, have great influence in lessening ground exhalations. The ground air, therefore, is in continual movement owing to diurnal changes of temperature, the fall of rain which at first displaces the superficial air and later drives it out from below by raising the level of the ground water, barometric pressure, and winds. A house artificially warmed and not furnished with an impermeable basement draws up air from below from considerable distances and from cess-pools and leaky drains if they exist beneath or near it. Hence the unhealthiness of houses on made soils. Heavy rain forces out ground air, and, as rain does not fall within houses, the ground air tends to escape most readily through their floors, if permeable. This fact may possibly have some connection with the increased mortality which follows the rains in India.

---

* This is probably formed by the detritus of luxuriant *ramnah* grass which covers this part of the country at one season and is only partly harvested.

† Such a deposit exists under the sand at Bagshot in England and contaminates the well-water.

Water in Soil.

More or less *moisture* exists in all soils, even in the most compact rocks. Some soils, such as heavy clays, are very tenacious of moisture, while others, such as pure sands, are easily dried. Moisture does not, as a rule, fill up all the spaces between the particles of soil, but merely forms a coating upon these particles, or is absorbed by organic matter in the soil, or exists in a loose state of combination with some mineral substances. In damp soils the contained air is saturated with watery vapour. Moisture in soil is an essential factor of decomposition and promotes the growth of animal and vegetable life including that of the numerous micro-organisms which may exist in the ground. Dampness of soil is one of the most important and common of the causes which render certain localities less healthy than others. Phthisis and rheumatism are particularly prevalent on cold, damp soils. Numerous instances are known where an increase of dampness produced by irrigation works or by obstruction to drainage* has resulted in a great increase of sickness and mortality from malarial fevers.

Sub-soil water is the term usually applied to water which fills all the interspaces in a porous soil. It flows, more or less slowly, through the lower layers of such a soil where it rests upon impermeable rock or clay. This is the first water which is tapped on digging a hole in the ground and furnishes the supply of shallow wells. The depth of sub-soil water from the surface of the ground varies much in different places and at different seasons; in some localities, with considerable inclination, it may all run off rapidly after rain, and none may be found in dry seasons. Sub-soil water influences the moisture of the ground and of the air above it as well as the amount of ground air. When it is only a few feet or less from the surface the ground above must always be damp. When sub-soil water rises it displaces a proportionate quantity of ground air, and when it falls more air enters the ground, which is left moist and in a condition to favor decomposition and the growth of microbes. It is therefore apparent that, where the level of sub-soil water can be regulated, it should be kept (1) as low as possible and (2) at a constant level. The sub-soil or ground water is always in motion towards its outfall, a river or the sea. Its rate of flow depends on the inclination of the impermeable strata which direct its course and on the porosity and density of the soil it has to traverse. If near the surface its flow may be assisted and its level consequently lowered by cutting deep trenches or laying unjointed porous pipes in the soil which afford the water an easier and quicker route than through the interstices of the soil. The flow may, on the other hand, be obstructed by great engineering works such as railway embankments, and a formerly dry and healthy locality may thus become damp and unhealthy. In alluvial soils, where alternate strata of sand and clay are found irregularly mingled, an area which is damp, owing to the rain water being held up in a cup-like depression of clay, may sometimes be completely drained and dried by digging through the impermeable stratum of clay, and thus allowing the water to drain away into the sand beneath. The same arrangement of the sub-soil sometimes leads to disappointment when persons endeavour to obtain more water by deepening a well or tank, for, instead of obtaining more, they lose all that the well or tank contained if they penetrate the clay layer and get into a layer of sand which does not hold water or is not saturated. This accident is not unheard of in Madras.

---

* The cases of the Ganges and Jumna irrigation canals, silting up of channels in Burdwan, and on a smaller scale at Kambam (*vide* Mr. Farmer's Report) may be mentioned as examples.

Healthy and Unhealthy Soils.

The geological and chemical characters of soil affect its healthiness in so far as they influence the conformation and material of its surface, the vegetation which it supports, the amount and nature of dust and other impurities which it yields to the air, its permeability by air and water, its capacity for retaining water on the surface or in the sub-soil, and the impurities which it yields to water.

When the surface is considerably inclined, a soil is more likely to be dry than when it is level, as a large proportion of rain runs without sinking into the ground, and the deeper strata are also likely to be inclined and to promote deep drainage. For this reason hills are well drained and their soil is comparatively dry, although more rain falls upon them than upon adjacent plains. The soil of valleys and plains at the foot of hills is generally very moist and rich in organic matter derived from the remains of plants washed down from the hills as well as from the local luxuriance of vegetable and animal life. Impurities emanating from the soil are apt to accumulate in the often motionless air of sheltered valleys.

An impermeable surface, such as one of granite, trap, slate or limestone rock, is very dry unless there are cavities which retain water. A less impervious surface formed of dense clay, although it does not allow water to pass through it very readily, is very retentive of moisture and is damp unless drained artificially. Pervious soils, formed of gravel, sand, light clay or sand-stone, are generally very healthy if dry, that is, if the drainage be unobstructed and the level of sub-soil water be low and not subject to great fluctuation. Such soil, however, may be malarious during light rain or after heavy rain. Water-logged soils and marshes in which the sub-soil water is close to the surface are unhealthy and often malarious. Alluvial soils, deposited by rivers, and found also in the beds of tanks and in deep valleys and other hollows, consist of clay and sand mixed with a large proportion of vegetable matter; they are usually unhealthy owing to their dampness, their level flatness impeding drainage, and to the impurity which they communicate to the water. Soils of this kind are greatly improved by drainage and by measures which render their surface less permeable. Hollows and irregular water-courses, where decaying vegetable matter accumulates, are sometimes local causes of unhealthiness which can generally be rectified.

Made soils, consisting of sweepings and dry rubbish of all kinds from towns are very unhealthy but improve in course of time, especially if well drained. A deposit of rubbish if heaped up on high and well drained may lack sufficient moisture for its due disintegration, since the process can only go on while rain supplies the necessary water during a short period of the year (*vide* page 108 in chapter on Removal of Waste). The natural purification of made and polluted soils is exactly comparable to that which takes place in polluted water and in the biological treatment of sewage. The complex organic substances are used as food by micro-organisms and gradually changed to innocuous mineral salts which are slowly removed by the percolating rain water. Gases are given off during the process which add impurity to the air in the neighbourhood of a rubbish heap. Until made soil is completely purified it should not be used for building purposes.

Reflection and absorption of heat and light depend a good deal upon the dryness and colour of the surface. A bare light-coloured soil may reflect light so strongly as to be injurious to the eyes and brain. Dry sand and rocks form the hottest surfaces; damp clays and surfaces clothed with vegetation, the coolest.

The influence of vegetation is very important. Short herbage and trees are generally healthy, while brush-wood and rank herbage are deleterious. Trees keep the surface 1 of the ground cool by protecting it from the sun, thus diminishing exhalation from the soil; they promote dryness 2 of the soil and coolness of air in damp places by taking up moisture from their roots and evaporating it on the great extent of surface afforded by their leaves, the amount of water so evaporated being much greater than that which would pass off from the surface of the ground shaded by the 3 trees; they feed upon matters which pollute the soil and the air and thus act as purifying agents. They may act injuri- 4 ously by obstructing movement of air and drainage of soil and increasing moisture of air; but belts of trees may also be useful to protect from malaria by offering obstruction to the flight of mosquitoes from their breeding places. Brushwood is generally bad; it adds to the organic impurity on the surface and obstructs the passage of air, the oxidation of surface impurities and the growth of herbage, while it keeps the surface damp and may promote the growth of *fungi* and other injurious organisms. Long rank herbage may act in a similar way. Short herbage, however, is always beneficial; it keeps the surface cool, promotes evaporation, lessens exhalation and dust, feeds on impurities.

Dry cultivation, for similar reasons improves the healthiness of a locality. Regular tillage appears to be always beneficial. Wet cultivation, however, is not, as a rule, favourable to health, but it is probably more so than allowing damp lands to remain uncultivated.

Improvement of Unhealthy Soils.

Few individuals can select their place of residence, and existing centres of population cannot be moved to healthier sites. The sanitary question in relation to soil, therefore, usually resolves itself into the improvement of present sites.

Dampness and the presence of decaying organic matter in the soil or on its surface are the two principal causes of unhealthiness. The former may be mitigated by drainage, the latter by oxidation and vegetation. Drainage may be distinguished into that of the surface and that of the sub-soil. Surface drainage provides for the carrying off of rain-water (with some surface impurities) instead of allowing it to sink into the soil. Sub-soil drainage provides, by means of deep or underground channels, for the removal of water contained in the soil or for lowering the level of sub-soil water. Sub-soil drains are usually made by loosely jointed or perforated earthenware pipes or even a layer of large stones in deep channels which are then covered in with earth. Large channels for sub-soil drainage are usually open. The removal of obstructions in natural drainage channels is often sufficient to cause a marked improvement in the dryness and healthiness of a place.*

Oxidation of organic matter in the soil is promoted by free access of air and by drainage which allows air to permeate the soil. The removal of brush-wood and regular tillage are most important aids.

Sanitary and Engineering authorities are all agreed that irrigation without drainage has a most evil influence upon health, and that deep drainage improves the soil as well as the health of the inhabitants. The efficiency of drainage should especially be looked to in irrigated lands. In most parts of Madras the natural drainage is good, but in some parts of Northern India flat tracts of sedimentary soil occur where irrigation water has no sufficient outflows, and in such places malaria prevails to an alarming extent. For instance in 1885, in the town of Sunpat on the Delhi branch of the Jumna canal there were 833 deaths from fever in a population of 13,077, a rate of 62·93 per 1000 per annum.†

If for any reason improvement of an unhealthy damp soil by drainage and cultivation is impracticable, a considerable degree of improvement may be attained by other measures, such as raising the level of the ground by cartage of soil from a distance, rendering the surface more or less impervious by pavement or other means, or covering an unhealthy area of land with a sheet of water.

The management of irrigation is a most important matter. If an increased volume of water be poured into a district, the channels, natural or artificial, which were previously sufficient for its drainage may prove insufficient; a general stagnation and rise of sub-soil water and greatly increased unhealthiness may result. Hence when irrigation is resorted to, drainage should receive especial attention.

---

* The ancient Romans fully recognised the importance of dryness of soil. Old and now silted-up sub-soil drains are to be found under the remains of their houses and in the country about Rome. The latter were also apparently used for collecting water in wells.

† *Evils of Canal Irrigation and their Prevention*, by T. H. Thornton, C.S.I., Journal Society of Arts, March 1888.

Wet cultivation should not be encouraged in the immediate vicinity of houses; but it is probable that damp, undrained, soils are more unhealthy if left uncultivated than when subjected to wet cultivation, and it is generally impracticable to arrest the irrigation (and thus the food supply and revenue) of large tracts of land round towns and villages.

The *humus* layer of the soil with its contained micro-organisms exerts a most important influence in the world. In it all the waste animal and vegetable organic matter of the world is changed into substances available for the food of plants; without it the surface of the earth would soon be covered with putrefying material, and life could not continue. The more organic matter contained in the humus the more micro-organisms there are, and the greater number of these are found near the surface. The purifying power of the soil is, however, limited, and, if more organic matter is put into it than the bacteria can deal with, the air above it, the water that flows beneath it, and the soil itself become loaded with imperfectly oxidized poisonous products. Instances of this are furnished by ill-managed sewage farms which are supplied with more sewage than can be dealt with, and in nature by marshes and certain parts of virgin forests.

Most of the organisms found in the soil are harmless saprophytes, but many pathogenic organisms, if accidentally introduced, can live and multiply for variable periods. Some are found with such frequency that the soil must be looked upon as their natural habitat. Two of these are exceedingly common in India, the bacilli of tetanus and of malignant œdema. In street accidents when wounds get filled with dirt these bacilli also find an entrance, and fatal results not unfrequently follow even an insignificant wound.

The relation of the soil to malaria will be considered when we come to the section on diseases.

II. CLIMATE.*

Climate is generally understood to mean local characters and changes of the air with regard to temperature, moisture, pressure, wind, cloud, rain, purity, electric state, as well as local amount and intensity of the sun's heat and light. In considering the effect upon health of residence in any particular place, all other local conditions have also to be taken into account. That climatic conditions have a very pronounced effect upon health is proved by the geographical distribution of diseases, and still more so by their seasonal prevalence. Some knowledge of physiography * is necessary in order to fully understand all the phenomena of climate, and the influence exerted by relative proportion of land and water, hot or cold winds and ocean currents, mountains, altitude, character of the surface, and other local conditions which are of secondary importance only to latitude in determining those phenomena.

---

* *Climates and Weather of India* by H. F. Blandford, F.R.S., is an excellent work which should be consulted for local information

Temperature.

Temperature affords the most usual basis for the classification, and the simplest division is into hot, temperate and cold. But in places with the same mean temperature the extreme fluctuations may be very great or very small. In islands and on the sea coast the difference between the hottest and coldest seasons is least marked and such a climate is termed equable. On the other hand, the climate of regions far inland is extreme, being very cold in winter and very hot in summer.† Besides annual fluctuations both daily and irregular fluctuations also occur; in constant climates such fluctuations are small, while in inconstant or variable climates they are great, there being much difference between the day and night temperatures or frequent, sudden, unseasonable changes. Inland and temperate climates are generally the most variable, hot island and coast climates the most constant.

Temperature has an important influence upon health. Variable temperate climates and climates subject to extreme differences between hot and cold seasons are those which produce the most vigorous races of mankind; this is probably due to natural selection, for weakly people are constantly killed by great changes of temperature. Constant and equable climates on the other hand, especially when hot, moist, and well supplied with food, tend to produce a weakly and languid race of men. The prevalence of particular diseases is much affected by temperature; in cold and changeable climates diseases of the lungs are very prevalent and fatal, and rheumatism is frequent, while in hot climates diseases of the bowels and liver and malarial fevers are very common. Some diseases, such as malaria and cholera, are arrested by cold; and high temperature, combined with dryness, arrests plague and is unfavourable to other diseases. Exposure to the direct heat of the sun in hot climates sometimes produces an intense form of fever (sun fever) which is speedily fatal or else ends in recovery within a few days. Heat apoplexy is more frequently caused by very high temperature in the shade than by exposure to the sun; it is very rare except in persons who are in bad health or of intemperate habits.

---

* Huxley's *Physiography* may be consulted.

† As an example it may be mentioned that the difference between the mean temperature of the hottest and of the coldest month in Madras is only 12° F., while in Peshawar the difference is 39° F.

Moisture.

The quantity of watery vapour which air is capable of containing increases rapidly with rise of temperature. For instance, at freezing-point it can contain only 2 grains of moisture per cubic foot, while at 70° F. it can contain 8 grains. Therefore air which is saturated with watery vapour or exceedingly damp at a low temperature becomes relatively very dry when its temperature is much raised, although the absolute quantity of moisture contained in it remains the same. The absolute quantity of moisture contained in air is therefore much less important than the quantity in relation to temperature. The latter is usually expressed as percentage of the quantity required for saturation at the given temperature. Thus air at a temperature of 70° F. containing 4 grains of aqueous vapour per cubic foot would be said to have a humidity of 50 per cent.

From this it will be understood how air which is relatively dry at a high temperature becomes moistened and even saturated as its temperature is lowered. If the temperature be lowered below the point of saturation (*dew-point*), the excess of moisture is deposited in the form of water, as dew, rain, cloud, mist. Hence the dampness of cool evening air and the deposit of dew on cold surfaces. On the other hand, when the temperature of saturated air is raised, it becomes relatively dry and capable of taking up more moisture, and the hotter it becomes, the more does it encourage evaporation.

Temperature therefore has great influence upon the moisture of the air, so also have large bodies of water and the nature of the surface. Mountains, as the Western Ghats during the south-west monsoon, deprive winds passing over them of much moisture and cool them, but render the climate more variable at the other side by removing vapour from the air. The presence of aqueous vapour in the air, even when not deposited in the form of cloud, obstructs the passage of heat.* Thus in places where the air is damp the heat of the sun is slightly moderated, but rapid radiation of heat from the ground is considerably prevented, the climate being thus rendered equable. Dryness of the air, on the contrary, favours great solar heat in the day-time and rapid radiation from the ground, causing comparatively hot days and cold nights. Moisture further tends to produce equability of climate by the cooling effect of evaporation when the air is heated and by the liberation of latent heat when vapour is condensed as the air cools.

Moist climates are, other things being equal, undoubtedly less healthy than dry ones. Many reasons may be assigned for this. Moisture of air and of soil generally go together, and the evil effects of moisture of soil have been already noticed. Micro-organisms multiply more readily and are more abundant in moist than in dry air. Moisture is an essential factor in the production of putrefaction. Evaporation from the skin and lungs and capacity for exertion are lessened by moisture of air.

The mean annual moisture of air on the coasts of India is about 70, and in the Deccan and dry parts of Northern India about 55 per cent. of saturation quantity. On the coast the range is small, about 20; in the interior it varies from 30 to 50.

Pressure.

The pressure of air at the sea-level is equal to that of about 760 millimeters (30 inches) of mercury, or about 34 feet of water, or a weight of 15 pounds on every square inch of surface. As we ascend above the level of the sea this pressure diminishes, thus at Bangalore it is equal to that of 27·7 inches of mercury and at Ootacamund of only 23½ inches. The effect of diminished pressure is to cause expansion of the air and to encourage evaporation. The small changes of pressure observed in any one place can have no perceptible effect upon health. The physiological effect of considerably diminished pressure is to increase the rapidity of the respiration and the pulse; but no injurious effect is produced upon previously healthy persons by a diminution of pressure such as occurs up to an altitude of 9,000 feet above the sea.

---

* Aqueous vapour obstructs the heat of the sun much less than that radiated from the ground.—*Tyndall.*

In considering the effect of high altitudes above the sea level upon climate and upon health, other factors, besides diminished atmospheric pressure, have to be taken into account. Thus the temperature becomes lower as we ascend,* radiation of heat being much increased by the lessened thickness of air and greatly lessened amount of aqueous vapour through which it has to pass. The air of high regions is often very dry owing to good drainage of the ground, rapid evaporation and free movement of air. Increased purity of air is one of the factors of healthiness in such places; impurities of all kinds including micro-organisms, rapidly diminish as we ascend. Well-drained soil, pure air, pure water, lower temperature, and often increased exercise, are, more probably than any effect of diminished air pressure, the real causes of healthiness in hill climates.

Wind.

Stagnation of air greatly favours the accumulation of all kinds of impurities in it and lessens the rapidity of oxidation. Constant movement of air is therefore beneficial. Such movement, and indeed wind generally, is caused by alterations of temperature. Wind may perhaps in some cases transport the material of the disease. It certainly does so for some distance in the case of malaria. The good effect of wind in dispersing and destroying organic impurities is, however, far more predominant than any injurious effect. The temperature and moisture of the wind, depending upon the surface over which it has blown, has often a very marked influence upon the climate of a locality. Though moderate movement of the air is beneficial, violent movement is not so. High winds, especially if cold, are likely, by chilling the skin, to excite congestion of internal organs, and they may increase the impurity of air by raising dust.

---

* Glaisher found the diminution to be about 4° F. for every inch of fall in barometer.

Cloud.

When moisture-laden air becomes cooled (to below the dew-point) from any cause, such as meeting a current of colder air, cloud or mist results, or large drops of rain may be formed. Clouds thus denote a super saturated condition of the air in which they exist. The air near the ground may, however, be dry, while clouds exist higher up. The effect of clouds is to promote coolness of climate by arresting heat from the sun and equability by arresting radiation of heat from the earth. They may exert an unfavourable influence by interfering with light which is required for the health of plants and animals.

Rain.

Rain is beneficial by washing impurities from the air and supplying necessary water, besides cooling the air. Heavy rain washes impurities from the surface of the ground into the soil and into water-courses, and is unfavourable to the production of malaria during its continuance. Light rain encourages decomposition of substances upon and in the soil, the growth of microbes, and the production of malaria. Therefore in places with a heavy rainfall we find fever most prevalent some time after rain, and in places with a light rainfall it prevails during the rains. The effect of rain upon moisture of air and soil is obvious. There is often a remarkable contrast between the amounts of rain which fall in one place at different seasons of the year, and the total amount at different places also shows extreme contrasts.

Purity of air has been already discussed in the Chapter on Air. Little is known regarding the influence of electric conditions of the air upon health.

The Sun

is the cause, directly or remotely, of all energy upon the earth. This energy is transmitted in the first place as radiant heat and light. Green plants especially, and most animals to a lesser degree, require heat and light for their development. Green plants under the influence of light decompose the carbon dioxide gas which is evolved by animals and by the decomposition of organic substances. The direct heat of the sun* is useful in promoting dryness of the surface and probably in destroying micro-organisms, as well as in causing currents of air. Moderate exposure to it is beneficial to men in cool climates, and is not necessarily detrimental to their health in hot climates*. Light, however, is much more necessary and conducive to health than heat, though its mode of action on animals is not well understood. A part of the good effect attributed to it is, no doubt, due to the usually coincident good ventilation and often out-door exercise. Excessive light, as reflection from a light-coloured soil or from snow, is very prejudicial to the eyes, and through them may even affect the brain.

---

* Sometimes marking a temperature of 170° F. or even more.

III. METEOROLOGY

is the science of observation of climatic phenomena. In the reports on the meteorology of India observations of the following points are recorded, being collected from numerous observatories in every part of India :—

(1) Solar radiation and duration of bright sunshine.
(2) Nocturnal radiation and temperature of the ground.
(3) Temperature of the air.
(4) Atmospheric pressure.
(5) Wind direction and movement.
(6) Hygrometry.
(7) Cloud proportion.
(8) Rainfall.

Temperature of solar radiation is a measure of direct heat of the sun. The solar radiation thermometer is a self-registering mercurial thermometer, having the bulb and half an inch of the stem coated with lamp-black, and it is enclosed in a large glass tube from which the air is exhausted. The bulb is blackened to render it more absorbent of heat, and the outer tube serves to protect it from currents of air. This thermometer is easily affected by surrounding objects. It is corrected by comparison with an arbitrary standard instrument.

The duration of bright sunshine is measured in a few places by the sunshine-recorder,† which consists of a spherical glass lens having a curved brass plate fixed beneath it at such a distance that the focal point in which the sun's rays converge travels across the surface of the plate between sunrise and sunset. A slip of card, with printed divisions corresponding to hours, is inserted in grooves on the plate, so that when the sun shines brightly a line is burnt on it; measurement of this line gives the time of bright sunshine.

---

* In hot climates indeed the most vigorous and hardy people have a good deal of such exposure. The Arabs and Persians speak with contempt of "shade-nurtured" weaklings.

† Invented by Mr. Campbell and improved by Professor G. Stokes.

Nocturnal radiation from the ground is measured by a minimum self-registering spirit thermometer laid on a thick pad of common country blanket which affords a more uniform radiating surface than grass or bare ground. The temperature of the ground at various depths is observed at only a few stations.

Temperature of the air is observed in most places only twice daily, at 10 A.M. and 4 P.M., by means of an ordinary mercurial thermometer (the dry bulb of the *dry and wet bulbs*). The readings, together with those of the maximum and minimum thermometers, afford the data for the deduction of the mean temperature. The highest and lowest temperature of the air in the shade is recorded by means of a mercurial self-registering maximum and a spirit self-registering minimum thermometer, the indices of which must be set daily after reading. These thermometers are kept in a cage fixed to one of the supports of a thatched shed, open all round, the bulbs of the thermometers being 4 to 4½ feet above the ground.

The atmospheric pressure is measured by a mercurial barometer.* The barometers are kept in masonry buildings to protect them as much as possible from changes of temperature. The mean pressure is determined from two (sometimes three or four) daily readings, in some cases corrected by results of hourly observations in former years. The corrections of the readings for temperature, etc., are made in the central offices.

Wind.—The direction is observed at 10 A.M. and 4 P.M. The anemometer reading shows the amount of wind in miles.

Hygrometry.—The moisture of the air is calculated from the difference between the readings of the dry and wet bulb thermometers at 10 A.M. and 4 P.M. and by the minimum dry and wet bulb readings. These instruments must be freely exposed to the wind in the thermometer shed. Not only humidity but altitude and temperature of air influence the temperature of evaporation (wet bulb).

Cloud is estimated in the usual way by looking all round, overcast sky being noted as 10 and cloudless sky as 0. Observations are made at 10 A.M. and 4 P.M.

Rain is generally measured at 6 P.M.

---

* Most of those in use are on Fortin's principle.

The method of using Meteorological Instruments must be learned practically at a meteorological observatory or a physical laboratory. Full descriptions of these instruments would therefore be superfluous in this place. The principle only of the most important instruments will be briefly explained.

The barometer is a balance for weighing the pressure of the air. Mercury is used because it is the heaviest known liquid. When a long tube, closed at one end, is filled with mercury and its open end is inverted in a cup or cistern full of mercury, the pressure of the air on the surface of the mercury in the cup keeps the mercury in the tube pressed up to a height of about 30 inches, supposing the experiment to be performed at the sea-level. As we ascend above the sea-level, the weight of the air above us, and consequently the height of mercury in the barometer tube, becomes less and less. Therefore the barometer may be used for ascertaining the height of any place above the level of the sea. The following table shows the number of feet ascended for each inch fall of the mercury from 30 inches to 22 inches:—

Inches of mercury	29	28	27	26	25	24	23	22
Height in feet for every inch.	886	918	951	986	1,025	1,068	1,113	1,161
Total height ...	886	1,804	2,755	3,741	4,766	5,834	6,947	8,108

The fluctuations of the barometer in one place indicate changes in the density of the atmosphere above. These are mainly due to variations of temperature and moisture and air currents, which may occur in the upper regions of the air as well as near the surface of the ground.

The aneroid barometer is a very portable instrument. Its indications depend upon the contraction or expansion, under the influence of atmosphere pressure, of an elastic metal box from which the air has been partly exhausted. It is regulated by comparison with a mercurial barometer.

Thermometers are instruments for measuring the intensity of heat. The expansion of mercury is commonly employed for the purpose, mercury being selected because it is affected by small quantities of heat and expands equably at different temperatures.

The maximum thermometer is provided with an index which is pushed up by the column of mercury and remains at the highest point reached.

The minimum thermometer is made with alcohol instead of mercury, and contains an index which is drawn down by the alcohol to the lowest point reached and is not pressed up by the ascending alcohol.

The wet bulb thermometer has its bulb constantly kept wet by an envelope of cotton cloth in communication with a cup containing water. This thermometer therefore gives the temperature produced by evaporation, and, as water in evaporating absorbs heat, it must always indicate a lower temperature than the dry bulb thermometer except when the air is saturated with moisture and no evaporation can take place. Other conditions being unchanged, the drier the air the greater will be the difference between the indications of the wet and dry bulb thermometers. The rapidity of evaporation is increased not only by dryness of air, but also by increase of temperature and diminution of pressure, conditions which have to be taken into account in calculating the moisture of the air from dry and wet bulb thermometer readings.

The rain gauge is an instrument for measuring the rainfall. It consists of a carefully-made funnel of exact calculated size at the rim and a measuring vessel in which the water is collected.* A commonly used size for the funnel is 4·697 inches in diameter; $\frac{1}{10}$ inch of rain falling into this gives 1 fluid ounce of water.

The anemometer is a self-recording instrument which shows the amount of wind. It consists essentially of a horizontal wheel with four spokes, each of which bears at its extremity a half-spherical cup. The pressure of the wind on the concave surface of such a cup is one-fourth more than on the convex surface.

---

* The square area of the circular aperture may be easily calculated ($d^2 \times 0{\cdot}7854$), and conversely we may calculate the size of circle equivalent to any given square surface.

CHAPTER VII.

HOUSES AND BUILDINGS.

Good health largely depends upon the healthiness of the houses in which people sleep and also spend a portion of the day. The two great causes of unhealthiness in houses are *damp* and *dirt.* Dirt is here taken in its most comprehensive sense as including foulness of soil, dust, rags, and refuse in and about the house, and foulness of air from contamination by such dust and refuse, deficient ventilation, latrine, sewer, or ground emanations and other causes.

Damp and dirt, especially when they co-exist, greatly encourage the growth of microbes and even of large *fungi;* it is a matter of common observation that circumstances which favour such growth are unfavourable to health even if the microbes present be not themselves specific causes of disease. Damp, dirt, and overcrowding not only encourage the spread of epidemic and all communicable diseases, but foster other diseases and produce a general low state of health by interfering with the physiological functions of the body, particularly those of the lungs and skin. The demolition and reconstruction of unhealthy houses has been attended with excellent results in many towns. For instance in Glasgow "it was proved by special investigation that the people whose wretched houses were demolished by the Improvement Trust distributed themselves over the city. It is often said that the habits of these people are such that, go where they please, they will not be the better for the change. It is evident, however, that they found physical conditions so much more conducive to health that, whether or not their habits have been improved, undoubtedly their health has been, in their new residences."* Demolition or improvement of insanitary dwellings in one direction is of little use, however, if the erection of similar dwellings in other directions is not prohibited. "If these places, which hardly anything short of clearance will remedy, are not to grow worse, and if other localities like them are not to spring into existence, building regulations which will effectually prevent huts and houses being built irrespective of ventilation, drainage, air-space, and means of scavengering must be enforced. In Calcutta, though considerable sums are being spent in endeavouring to improve unhealthy localities, equally unhealthy areas are arising."* In towns the effective control of building operations is comparatively easy, but in villages it is more difficult; the diffusion of hygienic education will do much to assist such control. No town can be very healthy or well-ordered where sanitary building regulations do not exist or are not enforced.

---

* *Vital Statistics of Glasgow* by J. B. Russel, M.D., LL.D.

The subjects of water-supply, drainage, sewage, and ventilation, all of which require attention in connection with houses, have been already treated of; but a few points regarding them may usefully be noted here. A supply of good water, if not delivered in the house, should be available within a reasonable distance. If the soil be permeable and damp, deep sub-soil drainage of the site should, if possible, be provided. In any case surface drainage should be attended to, and the surface should be rendered as impermeable as possible. Water and slops should not be thrown upon the ground, but be removed by proper drains. A syphon trap and ventilator should be provided between any sewer pipe leading from the interior of a house and its connection with the main sewer; the ventilator should be so placed that gases escaping from it may not enter the house—a ventilating pipe carried up to the top of the roof may be used. The latrine should be a separate building, or be placed against the outer wall of the house, with good separate ventilation and no direct passage into the house; it may be connected with the house by a covered passage open at the sides. The lighting and ventilation of each room should be separately arranged for; the superficial and cubic space to be provided (*vide* Chapter on Air) must be sufficient for the number of occupants; in addition to the windows and doors which can be closed, unclosable openings should exist sufficient for minimum ventilation.

Preparation of Site.

High, dry, sloping ground is the best, whether the soil be permeable or not. As a rule, however, the site of a house is not a matter of selection, and it has to be built where ground is available. If the soil be permeable, and particularly if it be damp, deep sub-soil drainage should be resorted to. If this cannot be done, the level may be raised by bringing clean earth or sand from another place. For small houses or huts a platform of loose stones may be made. Brushwood should be removed, hollows filled up, and surface drainage provided for.

---

* Report by Dr. Simpson, Medical officer of Health. *Indian Medical Gazette*, January 1887.

The Ground Floor

should be raised above the level of the ground outside so as to facilitate cleaning and promote dryness. It should be water and air tight in order to exclude damp and exhalations from the soil. For mud huts a thick flooring of well-puddled mud may be used. A coating of hydraulic cement should, if possible, be laid over this. If this is not done, special care should be taken to build on a high, dry platform and to make the floor as high as possible above the ground. In very damp places, wooden or bamboo huts * may, with advantage, be raised above the ground on piles, and large houses may be built on platforms raised on open brick or stone arches. The basement floor of large houses is best made of a thick layer of concrete. The level of the flooring in all houses and huts in India should be raised to form a *plinth* not less than 2 feet high. This serves to keep the house both drier and cleaner, and it is undoubtedly more healthy to be raised even that much above the general level of the ground. Expense incurred in bringing earth from a distance is the objection most frequently raised against the fulfilment of this regulation, and care must be taken to prevent pits being dug in the immediate neighbourhood to obtain the necessary earth as these frequently become stagnant pools filled with mosquito larvæ, and otherwise objectionable. The practice of excavating earth from the actual site of a hut to provide mud for its walls must be condemned, for the completed structure will have its floor from one to two feet below ground level.

Walls

are intended to exclude damp, great heat, great cold; the most suitable materials and method of construction will therefore largely depend upon climate; but the materials employed by the great majority of the population must be the least expensive and most readily obtainable. Mud is employed everywhere and sun-dried or even burnt bricks or stone bedded in mud or mortar, wood, and bamboo matting, plain, tarred, or plastered with mud, are used in various parts of the country. Impermeable materials are generally the best for walls because they effectually exclude damp from rain beating on them, do not soak it up from the ground, and do not absorb organic matter from air. To prevent damp rising from the ground in brick and mud walls, a *damp-proof course* should be inserted in the lower part of the walls. This is best made continuous with the damp-proof layer of the floor, and may be made of tarred brick, which would be a very cheap material for mud huts, or of hydraulic cement, impermeable stone set in cement, asphalte or vitrified tiles. A damp-proof course may be inserted in an existing wall without pulling it down.* Not only does a damp-proof course in the walls of a house render it drier and more healthy, but in the better class of house it is actually cheaper in the long run. Nothing is commoner than to see plaster flaking off walls and pillars, and badly burnt bricks disintegrating under the influence of the moisture which is continually soaking up from below. Double walls are effective in excluding damp, heat, and cold; the space between should be ventilated. For temporary or moveable huts, bamboo matting is an excellent material; it is very light and can be rendered air-tight or water-tight by plastering with mud or tarring or covering with tarred cloth. When plain, it provides excellent ventilation; nothing could be better for temporary or even permanent hospitals in hot climates; when dirty it can be washed, or burnt and replaced.† For the outside of walls, plaster or lime wash is often used, but this can have no particular hygienic effect. Hydraulic cement is good for excluding damp.

---

* *As in some parts of Burmah.*

For the interior a coating of some smooth impermeable material, which is non-absorbent and can be easily cleaned, is best.‡ This cannot commonly be provided however. Mud walls may be left plain or be white-washed from time to time with fresh-burnt lime. The common fashion of plastering walls and floors with cow-dung and water is decidedly to be condemned ; it renders them damp, affords material for the propagation of micro-organisms, and pollutes the air.

---

* A damp-proof course would also afford some protection against white-ants.

† It has been in use for some years in the contagious wards of the Madras General Hospital.

‡ Care must be taken not to use paint containing arsenic or other poisonous material. Arsenic occurs most commonly in green colours, and many cases of slow poisoning from their use have been recorded.

Upper Floors.

The value of land in towns and the convenience of being near their places of business is leading owners more and more to add upper floors to their houses. Generally speaking, there is no objection but it may happen that the street is so narrow that free perflation is obstructed by raising storeys all along it. Often too it happens that a second storey is added to a house which originally was never designed to bear one, the result being that light and air are almost completely shut off from the ground floor. Latrines and urinals in the second storey are not to be encouraged: they are almost unavoidably a nuisance.

Roofs

being designed to keep out rain and heat, while it is an advantage for them to permit some passage of air, are constructed in various ways, depending to a great extent upon the climate and the materials available. When the materials do not permit the passage of air, ridge-ventilation ought to be provided. Roofs made of thatch or other materials, which harbour insects and other vermin, may usefully be lined inside with tarred paper or matting.

For protecting against the heat of the sun the principal devices are thickness and non-conductibility of material, height,* light colour externally, and double roofs.

Rain water which falls on a roof should be carried off by channel pipes fixed to the eaves or else be received on a paved surface and be carried away by surface drains, so that it may not soak into the ground close to the walls.

Verandahs

are of great use in hot and wet countries to protect the side walls of a house from solar heat and from beating rain.

---

* In accordance with a well-known physical law, the heat radiated from a roof is inversely as the square of its distance. Therefore the direct heat reaching a person from a roof 5 feet above him is four times as much as would reach him if the roof were 10 feet above him.

They are also very useful as well-ventilated day-rooms and as sleeping places in sultry weather when the air is stagnant and ventilation fails within doors.

Out-houses and Stables

require as much attention as regular houses in order to preserve the health of persons residing in or near them and that of animals in them. Dryness, ventilation, good water-supply, drainage to remove urine and dirty water, and regular cleansing must all be looked to.

House interiors.

Much remains to be done in India in the way of designing commodious and sanitary buildings for the occupation of both natives and Europeans. Where sufficient space is available a good native house can easily be erected, but the worst types are found in towns, where the area to be built on is confined and often irregular. Desire for privacy leads to defective ventilation and lighting, and avarice on the part of the landlord generally leads to overcrowding. In Madras the Municipal Acts give power to the local authority to prevent insanitary buildings being erected ; and improvement in the future in the way of the gradual disappearance of unventilated and unlighted rooms, cook-rooms without smoke vents, porous brick floors, walls without damp-proof courses, latrines in inaccessible spots often adjoining a well either in the same or the next house, and the like, may be expected. Cattle and poultry should not be permitted to wander at will about the house. The latter especially often obtain their living only by careful search through dust-bins, heaps of garbage and even excreta in the streets. In the house the centre of attraction for them is naturally the cook-room, where during raids upon the victuals they may manage to shake off their feet the dirt picked up in the street. Railway companies and other public bodies often run up exceedingly insanitary buildings for their employés and coolies : any attempt of this nature must be resisted. The smaller the house the more necessary does free perflation become ; and back to back dwellings, which can get no through draught, are everywhere to be avoided.

The cleanliness of house interiors and yards is an important matter. The Hindu is not usually a sinner in this respect, though he has a habit of collecting refuse in out-of-the-way corners where it does not readily catch the eye. The custom that obtains amongst certain communities of covering the floors with matting is a most insanitary one when the mats are only removed at long intervals of years. By far the better plan is to have a cemented, tiled or mosaic floor as circumstances allow. This can be kept absolutely clean by swabbing with a wet cloth or mop. Brooms, together with the people who usually wield them, are better excluded from the insides of houses; they merely raise and displace dust without removing much of it.

Public Buildings

especially schools, hospitals and barracks, where persons are congregated in considerable numbers, require great attention to hygienic arrangements. Ample ventilation and water-supply is particularly necessary for hospitals. Hospitals and barracks however are generally well looked after, but schools are often completely neglected. This is a matter which requires special attention, not only with reference to the present health of children and the prevention of epidemics, but because "the child is the father of the man;" bad physical development tells throughout life, and insanitary habits acquired in childhood are with difficulty rectified. The hygienic condition of schools therefore in every respect deserves the greatest care. Instruction in the elements of hygiene should form part of the curriculum in all but infants' schools, and children should have an object lesson always before them in the shape of school buildings arranged on sanitary principles. The cubic space allotted in school rooms should be from 400—600 cubic feet per head according
to the age of the children. Spending long hours in an over-
d room has a distinctly bad effect in course of time
h physical and mental development. Somnolence and
ention in school is frequently due to overcrowding and
of proper ventilation. In order that a child may
it to the utmost by instruction his surroundings must
althy and the air pure. Bodily discomfort must have
dverse influence on the receptivity of a child's mind, for
best of times children have difficulty in fixing their
tion. While plenty of light is necessary to avoid strain
eyes in reading, a glare must be avoided. To lessen
ws in writing it is best for the light to come from the
ide. The height of the desks should be proportionate to
ize of the scholars, so that they can place both forearms

comfortably upon them without raising or depressing the shoulders. The height of the benches from the ground should be such that the feet do not dangle in mid air, but can be rested without elevating the knees. All seats should have proper backs, not merely a rail at the level of the shoulders. Enough pure drinking water must be supplied, and a latrine removed a little from the main building.

Plans of all new buildings should be passed by the sanitary authority before the work is allowed to be commenced, and, not only should the plan be carefully scrutinised, but the proposed site should also be inspected to make sure that existing sanitary arrangements are not likely to be interfered with, *e.g.*, that a latrine is not going to be built against a wall, behind which the neighbour has his well.

Markets, Slaughter-houses, Cattle-yards.

The essential sanitary points about a *market* are that it should be smoothly paved throughout and well drained to facilitate cleansing, that there should be a plentiful supply of water to wash down the stalls, and that meat and fish stalls should have no wood-work about them, with the exception of a chopping block. If funds permit a roof is desirable not only to keep out sun and rain but to exclude kites and crows. If the market be of any size a latrine is necessary. It should be roofed in and well ventilated and situated as far as possible from food stalls. None but stall-holders should be permitted to use it.

A slaughter-house should have a pen outside for collecting the animals prior to slaughter. Here also they can be conveniently inspected before admission to the main building. The slaughter house must be properly paved and drained throughout, and supplied with plenty of water for cleansing purposes. Whenever possible it should be connected with a sewer—special arrangements may be made for the collection of the blood which is valuable for making albumin and also for manure. A room where carcases can be hung for a while before sale, known in Madras as an "airing room," is a necessary adjunct. No latrine should be allowed in the building. A roof is necessary to keep out kites and crows which otherwise assemble in great numbers and cause much nuisance, and dogs must also be carefully excluded. Adjoining the slaughtering enclosure, but outside the wall, a paved area with stalls is generally required as an offal bazaar.

Cattle-yards are generally found in, or in close connection with, dwelling houses to the detriment of the health both of the cattle and of the human beings. If this cannot be avoided every care should be taken to keep the sheds as healthy as possible by proper impervious stone flooring and good ventilation. They must also be connected with a drain so that they can be thoroughly washed down. The storage of dung, the manufacture of bratties, uplis, or cow-dung cakes on the premises, and the practice of sticking them on to the walls of the cow-house to dry are to be condemned. Since small owners are generally unable to afford to keep their beasts under decently sanitary conditions, by far the better arrangement is to have public cattle-yards where a man can rent a few stalls and which can be properly supervised.

Bathing Places.

To discourage the custom of bathing in foul tanks where the bather washes not only his body and feet but also his clothes, and finally rinses out his mouth and spits a few times into the water before leaving it, public bathing places are extremely desirable, and are highly appreciated. A cemented enclosure, partitioned or not as required, with a plentiful supply of clean water laid on by pipes is all that is needed. Such places confer great benefits particularly on the poorer classes and lower castes.

CHAPTER VIII.

PERSONAL HYGIENE.

So many matters related to health are in the power of individuals themselves and of heads of families that this division of the subject is of wider practical importance than any other. Some of these matters have been already treated of; but any approach to a full discussion of all is here impossible. Other chapters must be referred to for much that is individually applicable: in this place only a few of the more salient points connected with personal hygiene can be alluded to.

Habit.

The persistence of acquired habits is a remarkable and controlling character of all organisms. Habits, however caused, are most easily originated in early life, become confirmed by practice (though the influence of the original cause may have been withdrawn), and are potent for good or evil upon individuals, communities, and posterity. The acquirement of good habits is, therefore, of supreme importance to all individuals as affecting the health and happiness of themselves, their neighbours, and their children.

It is especially with regard to the physical and mental training of children that the influence of habit can be most productive of good and most avertive of evil; the firm implanting of healthy habits and the eradication of unhealthy ones is the highest duty of parents and teachers. For the inculcation of hygienic habits some knowledge of hygiene is needful, but the most fruitful method of teaching them is by example in their practice. Hence parents and teachers should endeavour themselves to teach by practice, and should remember that the influence of a well-disciplined school or household and well-trained companions upon children has a most potent and abiding good effect.

It is difficult to break acquired habits, but the oftener they are broken, the more easy is it to destroy them; in the eradication of unhealthy habits as in the acquirement of healthy ones, the difficulty is half surmounted when the first effort has been made. As some guide towards the formation of healthy habits, the following points may be indicated: personal cleanliness; household cleanliness; regularity and punctuality; temperance in food, drink, sleep, sexual indulgence; mental and physical exercise, but avoidance of mental worry and great corporal fatigue; care in obtaining pure drinking water, wholesome food, and fresh air. Constant anxiety with regard to health is, however, a state of mind to be deprecated, and is not at all needed for the acquirement and practice of healthy habits; indeed it is often a consequence of ill-health and insanitary habits.

CUSTOM

has much power not only in the formation of social habits, but in the preservation of certain habits which are known and acknowledged to be bad. People do as their neighbours do, and even seem to think as their neighbours are believed to think, because they do not wish to appear singular. They would rather endure discomfort and possibly disease than face the scorn of custom or the pointing finger of ridicule. Those who would repeal the unwritten but binding laws of custom, when they clash with the laws of health, must sometimes brave both scorn and ridicule in the first place; but they will earn a certain reward from health and ultimately be accorded the respect and gratitude of weaker or more ignorant fellow-men.

The reform of evil social customs and training of children in good sanitary habits greatly depend upon the sound general and hygienic education of women, and any advance in this direction is to be hailed as a good presage by sanitarians. Not only the progress of household and personal hygiene, but the success attending public sanitation in any community must be in a large measure due to its wives and mothers, the presiding spirits of its houses and trainers of its children.

It may be useful to only mention a few of many noxious customs which education and good sense should reform. Such are intemperance, including eating to excess at festivals and entertainments; pollution of water which is used for drinking, by ablution of the person and of clothes in it and in other ways; too early and infant marriages, insanitary practices as to abstention from food, air, and cleanliness connected with parturient women and new-born children; suckling children after they have teeth and can run about; deficient exercise for women; funeral entertainments; various superstitious practices common to ignorant persons of all religions, such as shutting up the rooms of sick people to keep out evil spirits, prayer and charm healing with neglect of sanitary measures for infectious and other diseases, drinking foul water from holy places.

CLEANLINESS

in its most comprehensive sense embraces nearly all sanitation. Cleanliness of food, air, water, soil, and dwellings has been already noticed; a few lines must here be devoted to cleanliness of person.

Cleaning of the skin is particularly necessary in hot climates when the amount of watery sweat and solid excretion and desquamation from it is considerable, the skin performing a part of the function which belongs to the kidneys and lungs in colder climates. The effect of dirt and retained excretion upon the skin is to interfere with its action, prevent the contact of air which oxidises noxious impurities, and favor the production or propagation of some skin diseases. Most persons go through the form of washing their bodies daily with water, but the cleansing effect of such ablution is often very small. Unless soap, or some substitute for it, be employed, water especially hard water does not readily carry off the dirt, which is usually more or less greasy, from the skin. Friction of the skin during ablution, and with a towel or cloth afterwards, greatly assists cleansing. The very imperfect way in which ablution is usually performed is shown by the extensive prevalence of itch, ringworm, and other skin affections, and the frequent occurrence of lice, fleas, and bugs on the body and clothing. Want of attention to the cleanliness of the genital organs is a frequent cause of irritation and sometimes of disease. All parts where hair grows require special care in cleaning.

The employment of dirty water for washing is one cause of uncleanness and disease. Clean water, soap, and friction are the three requisites for cleaning the skin properly.

The practice of oil-inunction after bathing, as often used by the well-to-do, is specially beneficial to thin and aged persons.

Frequent cleaning of the mouth and teeth is a healthy custom, and serves to preserve the teeth and to get rid of remains of food and secretions which may decompose in the mouth. It is very important, however, that only the purest water, such as is used for drinking, should be employed for this purpose.

Cleanliness of clothing is a necessary accompaniment of cleanliness of skin. Frequent washing of inner garments is requisite. Clothes should be washed in clean water, and it is very desirable that the clothes belonging to different persons, or at all events those belonging to different families, should be kept separate, in order to prevent communication of disease. Skin diseases and small-pox are probably often communicated by clothes. The building and regulation of public washing-places would do much to promote cleanliness and prevent infection of clothing.

CLOTHING.

The principal object of clothing is to afford protection against heat and cold. Man, with his bare, sensitive, and porous skin requires such protection to enable him to bear extremes and vicissitudes of heat and cold, drought and damp. In cold and changeable climates clothing cannot be dispensed with; in warm and equable ones it is less necessary. The skin of persons accustomed to out-door exposure becomes thicker, harder, and less sensitive—consequently less in need of clothing—than that of persons who live more in houses, are generally more fully clad, and undergo less exposure.

The very young and very old are more sensitive to changes of temperature and more liable to suffer from congestions or inflammations in consequence of chills than are persons in middle life; young and old people therefore need especial care with regard to clothing. Young children in India are often much neglected in this way.

The secondary purposes of decency and ornament for which clothing is employed are of less hygienic importance. Ideas of decency and ornament vary much among different people; questions of taste do not concern us here: but when people distort and bind themselves injuriously, in obedience to the dictates of senseless fashions and false ideals of beauty and grace, it becomes the duty of sanitarians and sensible persons to protest and interfere.

Although Indian women have not, with rare exceptions, adopted the rigid corsets and high-heeled narrow boots which disfigure many of their European sisters, nor the scantiness of their evening dress, yet undue constriction of the waist is sometimes practised by them. Tight girdles or stays in children and adolescents impede the expansion and natural development of the chest, lungs, and heart, and injure general nutrition by interfering with the purification and circulation of the blood. Constriction of the waist is probably the most common cause of displacements of the womb which are a frequent source of suffering and ill health to fashionable women. Abdominal viscera also suffer; dyspepsia, constipation, or intestinal irritation may be sometimes due to tight lacing.

The common practice of sleeping with a sheet or blanket drawn over the face is objectionable, because exhalations from the skin or possibly dirty clothes are thus inhaled. It may perhaps be of advantage in some places by filtering out suspended impurities of air.

Cotton and wool are the commonest materials of which clothing is made. Linen is very similar to cotton, and silk to wool, in physical properties.

Cotton is much less absorbent of moisture, less permeable and a better conductor of heat than wool. Cotton consequently allows the perspiration of the skin to pass through it and conducts away the heat of the skin to the cold air outside; it thus offers little obstacle to rapid cooling of the skin, and is not well suited to form the only clothing in changeable climates and when the skin is perspiring after exertion. It is, however, easily washed, cheap and durable, and well adapted for ordinary clothing in equable climates and for under-garments in all climates.

Wool, on the other hand, is very absorbent of moisture and a very bad conductor of heat, while at the same time it is very permeable to air. It is therefore an excellent material for clothing especially in cold and changeable climates and when the skin is perspiring after exertion. The chilling effect of too rapid evaporation from the skin is prevented by the absorption of perspiration by wool and the evolution of latent heat from the aqueous vapour so condensed.*

---

* See some discussion on this subject in *Nature*, 1881. The large evolution of heat in this way may be shown, as in the author's experiments, by wrapping the bulb of a thermometer in dry silk or wool and then exposing it to very damp air: a rapid rise of the thermometer to the extent of 10° F., or more, is the result.

The warmth felt on investing the body with woollen clothing, especially when the skin is moist, is partly due to actual evolution of heat in this way and partly to the non-conduction of heat from the body to the outside air by the wool. The disadvantages of wool compared with cotton for under-clothing are its expensiveness and its not washing so well.

Impervious materials, such as greased leather and India-rubber, are useful for keeping out wet and retaining heat; but they retain the excretions of the skin and exclude purifying air, being therefore particularly objectionable in hot climates.

The color of clothing is of less consequence than the material; but black and dark colors are much more absorbent of heat than white and light colors. Poisonous coloring matters are sometimes employed for dyeing cloths; local irritation of the skin and even general ill-health may result.[*]

Exercise.

Disuse of muscles or other organs leads to more or less wasting of them: regular use of organs promotes their nutrition and growth. A moderate amount of exercise is therefore essential to the healthy development of the body in youth [†] and to its healthy maintenance throughout life. Many ailments of persons who, by occupation or choice, lead sedentary lives are due to neglect of the physiological rule of exercise. Persons of inactive habits frequently eat a great deal more than they need for the work which they perform—this is one cause of disease—but no care in dieting can make up for deficient exercise. A certain amount of exercise is essential for good health.

The connection between food and work has already been considered in the chapter on food; it only remains now to examine the other physiological aspects of exercise.

During exertion the greatest strain falls upon the heart, blood-vessels, and lungs, the circulation and respiration being largely increased. All the functions of nutrition and elimination are secondarily stimulated.* The appetite is increased and the amount of food taken must of course be proportioned to the amount of exercise.

---

[*] Arsenic is the most common injurious substance. It is an ingredient of several green pigments and may occur as an impurity in aniline dyes. The author lately found arsenic in some magenta-dyed socks which had caused an obstinate skin eruption in a patient at the Madras General Hospital.

[†] Physical training in schools is now recognised as an educational requisite of prime importance.

The best exercises for health are those which bring all the muscles of the body more or less into play, such as walking, riding, rowing. Exercise may sometimes be productive of evil effects. Thus violent or too long continued exertion, especially when there has been no gradual and regular training for it and when the food is insufficient, may be very injurious. Horses sometimes die from congestion of the lungs after violent exertion; and disease of the heart and blood-vessels is more common in men who occasionally make great efforts, such as artillerymen, oarsmen and athletes, than in those who practise less violent and more continuous exercise.

Training is necessary for any great or long continued exertion, in order to bring the various organs and tissues into proper state of nutrition and accommodation. Without gradual training lassitude soon occurs.

If food be habitually deficient, wasting results from much exercise. Exertion leading to fatigue, when the usual food cannot be obtained, causes great exhaustion and may produce fainting or cholera-like collapse.

Drinking during exercise is necessary and beneficial; it is better to drink frequently than to take large draughts at long intervals. Drinking cold water and bathing in cold water when the circulation is excited by exercise can do no harm to healthy persons.

After exertion when the body has began to cool and there is some sense of fatigue, woollen clothing should be put on. It is then that cold bathing and copious cold draughts are dangerous.

---

* Dr. E Smith found the quantity of air inspired by a man walking at the rate of three miles an hour to be more than three times as much as was inspired by the same man lying down, and when walking at the rate of four miles an hour it was five times as much. The same observer found that the amount of carbon dioxide in expired air was increased in proportion to the work done, for instance 5 grains per minute were evolved during sleep and no less than 18 grains per minute when walking at the rate of three miles an hour. Pettenkofer and Voit obtained similar experimental results with regard to oxygen absorbed and carbon dioxide evolved.

Exercise may be estimated and measured in foot-tons, that is, the number of tons which would be raised to a height of one foot by the energy expended. Conditions differ so much that an exact standard cannot be laid down for the minimum amount of exercise which is necessary for the preservation of good health. A very moderate amount of exercise is represented by half a foot-ton daily for every pound of body weight, and it is doubtful if an adult could enjoy vigorous health when taking less exercise than this. From two to three foot-tons per pound weight is a fair day's work for a labourer. A man weighing 130 lbs. does 15 foot-tons of work for every mile he walks along the level. Systematic gymnastic and physical exercise in young, healthy and vigorous men leads to increase of weight and great chest development; the circumference of the latter may be enlarged by as much as 4 or 5 inches in the space of a few months.

Graduated physical exercises have of recent years been found of immense value, particularly in training recruits for armies, but to obtain the best results they must be conducted under educated supervision, and at the same time adequate nourishment must be provided. Not only bodily but also great mental improvement follows such training; alertness, dexterity, presence of mind, and endurance of fatigue are all acquired.

"A fine physique once gained is never wholly lost," and there can be no doubt that after such training a man is placed in a far better position as regards his power of resistance to disease than he was before. Care must be taken to develop the limbs and all the groups of muscles equally. Exercise of the upper limbs only and neglect of the lower produces an actual deformity which is sometimes seen in native gymnasts.

Given a fair intellect the man who comes to the front in life is the one who is possessed of most endurance, the one who can get through life with a little less sleep than his fellows and can do hard mental work for more hours on end and for longer periods. At the end of the year he has so many extra days' or weeks' work to his credit, time which persons gifted with less endurance had to spend in rest and recreation. Genius, though it may acquire notoriety, can effect little unless coupled with power to work.

In physical as in mental exercise exhaustion undoes all good and is directly productive of evil. At the present time

Indian youths of the student class not unfrequently do themselves serious injury, which may result in permanent disease of the heart, by undisciplined exercises with dumb-bells and such like in their desire to emulate Sandow, unaware that their bodies, often unaccustomed to ordinary games and further weakened by long hours of reading and sometimes insufficient food, are unable to respond. No youth in ordinary health is too weak to benefit by exercise, but the amount requires adjustment to his powers.

The rapidity with which work is done is far more important than the actual amount of work with regard to its effect as exercise. A comparatively small amount of work done in a short space of time is far more exhausting and imposes a much greater strain on the heart, lungs and muscles than a large amount of work done slowly. For this reason rapid exertion is best for those who work for health and pleasure and can only give a limited time to bodily exercise, while less speed is more suitable for those who have a large quantity of work to do.

TEMPERANCE.

in all things is one of the highest sanitary virtues. Intemperance in food has been already alluded to. Occasional excess in this way is less injurious than habitual excess; but the enormous eating, sometimes of unwholesome food, which takes place at wedding feasts and other entertainments, is often productive of acute illness, such as colic, diarrhœa, or dysentery, and sometimes death results.* Habitual intemperance in food causes dyspepsia, congestion of the liver, and other disorders which predispose to various diseases and are productive of much discomfort and materially shorten life.

Intemperance in drink is generally confined to alcoholic liquors. Habitual drinking of raw spirit, a vice increasingly prevalent in some places, is the worst form of such intemperance. Diseases of the liver and blood vessels are common results of this form of intemperance. As has been already said in the Chapter on Food, the drinking of alcoholic liquors, even in small quantities, is a dangerous luxury; excess is

---

[*] Some cases which reach the Chemical Examiner can hardly be attributed to any other cause.

not easily avoided, and, as a matter of fact, nearly all those who do take them at all do sometimes, if not frequently, take them in injurious quantity. It is in the experience of nearly every physician that "strictly temperate" persons, that is persons who are never even slightly intoxicated, do not rarely suffer from drinking too much alcohol. Statistics of friendly societies and of insurance offices distinctly prove that "total abstainers" from alcohol suffer much less from disease and live much longer than "moderate drinkers."

The practices of smoking opium or ganjah and of eating them in sweetmeats or otherwise are very prevalent in some parts of the country and are hardly less noxious than drinking alcohol to excess. The action of these drugs is unfortunately too well known to need description. The wretched condition, mentally and bodily, of persons who indulge in such practices, and the not uncommon commission of crimes during the delirium produced by ganjah, ought to deter others from indulgence in them. Tobacco smoking is much less injurious, and in most cases it is practised with no very obvious injury to health.

Mental Hygiene.

Mental education and soundness have great influence upon development and health. There is much evidence that mental impressions of a pregnant woman may affect the development of the fœtus in her womb. The secretion and quality of milk is also affected by mental emotions. It is notorious that anxiety, care, disappointment, and all depressing emotions, have a very injurious effect upon health, while a contented and self-controlled mind is conducive to good health. It is therefore most important that healthy habits of mind should be cultivated. There is necessarily constant action and re-action between the brain and the rest of the body: ill-health has an injurious effect upon the brain as upon other organs, and unhealthy action or disease of the brain re-acts upon general health.

Healthy development and maintenance of the brain, as of other organs, are promoted by moderate, regular, intermittent exercise. Training increases its capacity for work within certain limits; but overwork is attended with temporary or permanent evil results.

The question of education on hygienic principles is too large a subject for us to enter upon; but it may be pointed out that hours of study are often too long, that when attention flags or the mind wanders from the subject it is an indication of fatigue and it is time to desist or to change the subject, and that cultivation of the understanding is more advantageous and rational, though perhaps less attended to, than cultivation of the memory. Training is as necessary for great and prolonged efforts of mind as it is for great and prolonged efforts of muscle; sudden "cramming" for examinations and long hours of forced reading are apt to be attended with mental break down.

MARRIAGE.

It is needless to describe the varieties of monogamy and female or male polygamy which exist among various races and in various religions. The sexes being nearly equal in numbers, monogamy is and must remain the custom of the great majority. Certain questions regarding marriage are however of great sanitary, social, and State importance; those which more especially demand our attention are, so-called infant marriage, early marriage, inter-marriage of blood relations, and marriage in connection with diseases transmissible by heredity or otherwise. Infant betrothal is objectionable because the parties are disposed of irrespective of their consent and inclination and of disease or other occurrences in the long interval before consummation of the marriage can take place, because, by usage, a virgin widow is condemned to perpetual celibacy,* and because too early consummation of marriage is encouraged by it.

The question of early marriage, looked at from a purely physiological point of view, is easily disposed of. The effect of cohabitation at too early an age, before the physical development of the body is complete, is very injurious in both sexes. It prevents full and strong physical development of both, causes a lack of manliness and energy in the man, and exposes the immature woman to danger in child-bearing. The children of very youthful parents are probably less vigorous than those of matured parents: a mother who has to provide for the growth of her own body as well as for that of the child she is bearing is likely to starve both. It has been urged in favor of early marriage that the suppression of an important physiological function must be prejudicial to health, and, on this ground, marriage should take place in both sexes at puberty ; but it is a matter of common experience to many besides physicians that sexual indulgence before bodily growth is complete is disastrous to health.

---

* Professor Max Müller in his *Hibbert Lectures*, 1878, pp. 332-3 showed that infant marriage really opposed to Hindu religion, and that the religious argument in its favour cannot hold ground.

The mortality of the married under 20 years of age has also been shown by statistics[*] to be excessively high in both sexes. It must therefore be concluded that early marriage, that is, marriage before growth and bodily development are complete, is decidedly injurious to health.[†]

The question of early, in the sense of improvident, marriage has important bearings for the philanthropist, the political economist, and the sanitarian, which can be only briefly alluded to here. In countries where early marriage is a prevalent custom, not only are marriages more numerous, but the number of children born to each marriage is much larger than in countries where marriages are usually contracted later in life, with a more prudent regard for the means of rearing progeny.[‡] One result is that in populous countries where improvident marriages are the rule, the population tends to increase in a more rapid ratio than the means of subsistence and it is naturally reduced by the "misery check" [§] of famine and disease. In those countries, on the other hand, where later marriages regulated by prudential considerations regarding the support of children are the rule, the population increases more in proportion to the means of subsistence and is less liable to be thinned out by famine and disease. The voluntary "prudential check" to population, in the shape of provident

---

[*] French vital statistics quoted by Farr.

[†] "Manu wishes a young man to marry when he may become a Grihastha, *i.e.*, when he is about 24 years of age. As to the girl she is to marry when she is fit for it." *Max Müller* (letter to Mr. B. M. Malabari). As we have pointed out a girl cannot be considered really fit for marriage and the exhausting duties of maternity until her growth is complete.

[‡] Dr. Mathews Duncan gives the following returns from the Lying-in Hospital of St. George's in the East :—

Age of mother at marriage ...	15–19	20–24	25–29	30–34
Average fecundity	9·12	7·92	6·30	4·60

India may be taken as an example of a country where improvident marriages are the rule ; in England, on the other hand, statistics show that the marriage rate is influenced by prosperity and means of subsistence.

[§] Malthus.

marriage, is therefore often a wise and efficient provision against misery and disease. It has been argued that an early marrying race or class must "breed down" and supplant a later marrying race or class [*]. But there is a great fallacy in such an argument; the conditions are dissimilar. The more prolific early marrying race may, and is likely to be, less provident, less vigorous, less wealthy, and consequently much more affected by the "misery check" than the later marrying race who adopt the voluntary "prudential check." The same rule applies to individual families; the offspring of the more prudent and well-to-do is less subject to the "misery check" than that of the less prudent and the very poor.

It has also been advanced that in a rapidly breeding race improvement takes place by "survival of the fittest." The fittest under such circumstances, however, would be the fittest to exist under depraved conditions; and it can hardly be doubted therefore that early and improvident marriage and too rapid breeding are to be condemned on evolutionary principles as tending to degrade the race.

All these considerations indicate unmistakably that not only infantile marriages but all improvident marriages are fraught with evil to the family and to the race. No sudden change of social habits is possible, but it is a question of deep concern for all thoughtful and influential persons to gradually educate the masses to truer conceptions of the responsibilities and consequences of marriage[†]. Unfortunately the very poorest classes are the greatest offenders, as they are also the greatest slaves of custom, in this respect.

In comparing the circumstances of this country with those of other countries where more provident habits prevail, the effect of early marriage on population and mortality should not be lost sight of by sanitarians and administrators.

The intermarriage of blood relations is often objectionable because their progeny has a double chance of inheriting any weaknesses or tendencies to disease which are common to their ancestors. Nervous temperament of disease (including mental disease) is likely to be thus transmitted or increased.* On the other hand if the stock be a vigorous and healthy one, the intermarriage of relations may increase some desirable family qualities.†

---

[*] See *Inquiries into Human Faculty*, by F. Galton, 1883.

[†] "Little advance can be expected in morality until the producing of a large family is regarded in the same light as drunkenness or any other physical excess."—*J. S. Mill.*

Several diseases and tendencies to disease are hereditary. The marriage of persons actually affected with hereditary disease, such as syphilis and probably leprosy, should be discouraged as an immoral act fraught with evil to their offspring and tending to disseminate disease. The intermarriage of persons affected with or who have a family tendency to certain diseases, such as scrofula (including consumption), rheumatism, gout, insanity, is also to be discountenanced, because the children of such inter-marriage would have a double chance of inheriting the diseased tendency.

This subject cannot fitly be concluded without saying a few words upon the evil consequences of sexual abuses. The effects of venery in the young have been alluded to under the head of early marriage. Excessive sexual indulgence is very injurious in adult life, but doubly so in youth; it produces general nervous depression with mental and muscular weakness, and results in premature loss of sexual power, early aging, and sometimes in actual disease of some part of the nervous system. Over indulgence in married persons is often the result of ignorance, and in the unmarried it is encouraged by the stimulation of lewd companionship, obscene literature, and the lures of prostitution. Notwithstanding the custom of early marriage, various forms of sexual depravity occur among youths in this country, and it is a manifest duty of parents or guardians of children to explain to them, as soon as they reach the age of puberty, the nature of, and the dangers to health attending, such practices. They cannot be brought up in ignorance of sexual passion, and the sooner they are instructed in the mysteries of sexual physiology and have explained to them the necessity of controlling this passion and the danger of its abuse, the easier will it be for them to avoid the rocks which beset the path of ignorance. Healthy exercise of body and mind, unstimulating diet and chastity of thought render continence easy. There is no danger in continence but great danger in excess, and everything which stimulates the sexual passion may be a source of danger to health.

---

* *Cretinism* has been attributed to breeding in-and-in in small isolated communities.

† This fact is well-known to breeders of horses, farm stock, and dogs,

MATERNITY.

The health of pregnant women needs special attention not only for themselves but for the sake of their offspring. Unwholesome or insufficient food, excessive work, and depressing mental emotions or violent excitement are often more injurious to the offspring than to the mother. During the great famine, mothers who did not themselves exhibit any great bodily wasting often gave birth to extremely emaciated and evidently starved infants; a generous diet is therefore necessary for pregnant women.

During and after child-birth cleanliness of person, free ventilation of the lying-in room and a sufficiency of wholesome food for the mother must be provided.*

The prevalent custom of suckling children until they are three years old is injurious to the mother as well as to the child. The effect of prolonged lactation is very exhausting, and if a woman become pregnant during lactation, the nutrition of the fœtus in the womb is interfered with. A child ought as a rule to be weaned when its first teeth appear. A nursing mother requires almost as much care and nourishment as a pregnant woman: bad food, excessive work, or mental emotion may interfere with lactation or cause the milk secreted to be of injurious nature.

THE FOUR AGES OF MAN.

The lifetime of man may be divided into the four periods of infancy, youth, maturity, and old age.

The well-being of an infant depends almost entirely upon its mother. Infants should as a rule be suckled by their mothers; a foster-mother is, however, desirable when the mother is very feeble or is affected with some disease, such as scrofula, which may possibly be communicated to the infant.

---

* The native mode of treatment of women in accouchement is one of peculiar hardship and torture to the patient. Kanny Lall Dey: *Hindu Social Laws and Habits.*

If fed on cow's milk the addition of a little sugar is useful, and care should be taken to obtain the milk of a healthy cow. If there be any doubt the milk ought to be boiled. It is a common fault to feed infants too frequently; over-fed infants often cry because they suffer from indigestion and not because they want food. They should not as a rule be fed more frequently than at intervals of three hours, so that the digestive organs may have some periods of rest. Weaning should gradually take place when the teeth appear, or the infant is about eight months old. Small quantities of gruel may be given at first, and by degrees this may be supplemented by some easily digested solid food. The practice of distending the stomachs of infants and young children with large quantities of food such as is taken by adults is strongly to be reprobated. Large quantities of sweetmeats are objectionable, and highly-spiced articles of diet should also be avoided. Young children require to be fed more frequently than adults and (as explained in the Chapter on Food) need a larger relative quantity of food. The giving of opiates or stimulants to children need only be mentioned to be condemned.

The cleanliness of infants and children is too often neglected. When they are washed it is frequently by pouring cold water over them in a current of air, a likely method of inducing internal congestions. Immersion in water, or at all events protection from wind during ablution, and rapid drying by friction with a cloth is the proper practice.

No clothing is commonly worn by infants and young children in Southern India and they not rarely suffer from exposure to vicissitudes of temperature. It should be borne in mind that children are more sensitive to changes of temperature and possess less vital resistance than adults, consequently they need more rather than less protection.

The care of young persons during youth, the period of active development and growth, and the due inculcation at this time of habits of self-control and cleanliness, are matters of the highest possible importance which have been previously alluded to and need scarcely be further insisted upon here. The attention which is now being paid to physical culture in our schools is a step in the right direction and one which deserves further extension.

The period of adult life may be regarded as extending from the time when growth is complete, that is, between the ages of 20 and 26 years, and the time when decay begins, that is, in healthy persons, between the ages of 40 and 60 years. This is the period during which the bodily powers are in the highest state of development and activity, but the mental powers do not generally attain their full ripeness till towards its close.

In old age the hair becomes grey or white, the sight and hearing become less acute, muscular and digestive power diminish, sexual power declines, fat under the skin becomes absorbed, the skin becoming less elastic and more dry and wrinkled, the bones become hard and brittle, and the tissues of the body tend to degenerate. Old persons require more digestible food, warmer clothing and less work than adults.

VITALITY AND LONGEVITY.

It is notorious that some individuals are much more apt than others to contract disease, and they succumb more easily to it or recover more slowly and less perfectly. The vitality of such persons is low and they are as a rule short-lived. Others, on the contrary, do not readily contract disease and they recover from it more rapidly and perfectly. Such persons possess a high degree of vitality.

Vitality may be partly inherited and partly acquired. Healthy, vigorous, and long-lived ancestors tend to produce healthy, vigorous, and long-lived descendants. Healthy rearing and physical education of children has much influence in increasing or preserving their natural vitality; and throughout life, hygienic surroundings and habits affect the vitality of individuals in a favourable manner. On the other hand, all unhealthy surroundings and habits affect vitality unfavourably. Excesses of all kinds, such as in eating, in alcoholic drinks, and in venery, exert a powerful depressing influence. Most long-lived persons are of moderate habits, a little above average height, and of rather spare condition.* From all the evidence we possess, it must be inferred that, although vitality is in part an inherited quality, yet it is to a large extent within the power of individuals themselves to increase or reduce their own vitality.

---

* See *Report on Aged Persons* (Collective Investigation Committee of B.M.A.), by Professor Humphry, F. R. S., *British Medical Journal, March* 10, 1888.

Long life and good health are as much due to good vital resistance, whether hereditary or promoted by hygienic personal habits, as they are due to protection from exposure to disease. If the tissues of the body possess a vigorous life of their own, disease-microbes cannot readily destroy or grow upon them and they will recover rapidly from various causes of depression or irritation, which would impair or destroy tissues of lower vitality. To afford protection from exposure to disease is the main function of Public Hygiene; to increase vital resistance to it is mainly one of Personal Hygiene.

CHAPTER IX.

PREVENTION OF DISEASE— PHYSIOLOGICAL DISEASES, PARASITIC DISEASES.

Classification of Diseases.

For the prevention of disease in a scientific, that is in the most rational and effective manner, the causes of disease must be known with accuracy. But knowledge of these causes is still very imperfect, the causes of some diseases have been ascertained with more or less exactitude; some other diseases, though not yet traced to their sources, are, by analogy, believed to be of a nature similar to better-known diseases; yet other diseases exists whose causes are still obscure. The classification of diseases according to their nature must therefore be imperfect; still this appears to be the most correct method to adopt.

The simple divisions which were defined in the introductory chapter may be accepted as, at all events, provisionally suitable to the state of knowledge. Diseases of which the causes are known can readily be referred to the class of physiological or that of microbic or that of parasitic diseases. Diseases of which the causes are not yet known with certainty, but which present characters closely analogous to those of certain known diseases, should be classed with the diseases which they most resemble. Diseases whose origin and nature are obscure, but which may *possibly* be microbic or parasitic and communicable, it is safest to regard as though they were certainly microbic or parasitic and communicable. No harm can be done by treating a non-communicable disease in this way, while, if it prove to be communicable, measures will have been adopted to prevent its spread. Although diseases may be broadly divided into those three classes, yet diseases which are classed together may differ remarkably from one another. It often occurs, however, that some diseases in each class, though differing specifically from each other, possess certain common secondary characters and resemblances by which they may be naturally grouped together: groups or *natural orders* may thus be distinguished.

The division of diseases into classes and groups is of great assistance in discussing measures for their prevention; but even closely allied diseases present so many differences among themselves that the necessity of studying each disease separately must not be overlooked. This study, however, must remain the special province of medical experts; we shall here consider only the more general principles of prevention with particular allusion to but a few of the most important diseases.

PHYSIOLOGICAL DISEASES

are due to some local or general impairment or alteration of function, with or without sensible alteration of structure, and not caused by microbes or parasites.

The principal causes of these diseases are, heredity (individual or racial); deficient, excessive or improper food or exercise; climatic influences.

The organs and tissues of the body, even in health, produce, as results of their own disintegration and wear and tear, or by certain decompositions or fermentations of blood or other fluids, various materials, some of which are actively poisonous.

During health such effete materials are excreted by the kidneys, skin, bowels, or lungs, some being oxidised in the blood, and they are thus removed almost as fast as they are produced. Disease may result from their retention in the body owing to excessive production or defective excretion.

Poisonous products of this kind act with intensity in proportion to their quantity; their effects are rapidly manifested, there being no incubation; they are not capable of self-multiplication; they are not communicable by infection, contact, or inoculation. In these respects physiological differ markedly from microbic diseases. The following important groups are contained in this class:—

Malformations and weaknesses, hereditary or acquired.
Constitutional diseases, gout, diabetes, etc.
Dietetic diseases, dyspepsia, some forms of diarrhœa scurvy, starvation, obesity, rickets.
Chemical poisons, alcoholism, lead poisoning.

Morbid growths of tissue elements, tumors.
Degenerations, fatty, caseous, calcareous.
Local inflammations or functional derangements due to heat, cold, or mechanical or chemical irritants, surgical injuries.

Prevention of Physiological Diseases.

The prevention of these diseases, in so far as they are preventable, is mainly a question of personal hygiene. Many points connected with their prevention have already been noticed in the Chapters on Food and Personal Hygiene, and need not be repeated further than to observe that the measures which conduce to prevent these diseases by preserving the healthy physiological action of all the organs of the body—in other words, a healthy habit of body—serve to increase vital resistance and strengthen the tissues against the invasion of microbic diseases also. Morbid hereditary tendencies should be particularly combated. Health and disease are relative terms: it is hard to draw the line between them. Perfect health is an ideal state it is scarcely possible to attain to. The human body is so complex that some part is almost invariably disordered, and it is these excursions below "par" on the part of the different bodily functions which pave the way to the entrance of pathogenic microbes.

PARASITIC DISEASES.

All animals, except those of the minutest size and simplest structure, and many vegetables, are liable to the attacks of animal parasites. Everywhere we find that "big fleas have little fleas to bite 'em." Many parasites confine their attacks to particular species of animals and cannot live upon other species; others are more indiscriminate, being capable of living upon even widely different species; while yet others require two species of animals for their complete development, passing the first or larval stage of their existence in one animal, and the second or mature stage in another animal. Some parasites also pass a portion of their lives in a free non-parasitic state.

Animal parasites (like microbic and larger vegetable parasites) are most likely to attack individuals of low vitality, the diseased, underfed, very young and very old; but good health is no guarantee against the attacks of many of them.

Some human parasites, such as hydatids, blood filariæ, and trichinæ, occasion serious disease and frequently death; others, such as tape-worms, round-worms, flukes, and guinea-worm, less frequently cause dangerous disease and rarely death; others, such as thread-worms, itch acari, and lice, are not apt to affect health except by the local discomfort or injury to which they give rise; while others, such as some protozoa found in the intestinal canal and some mucous tracts, appear to be harmless to their hosts.

Some parasites are permanently parasitic, that is, they cannot exist apart from their hosts; others, such as fleas, bugs, ticks, mosquitoes, leeches, flies, and the larvæ of flies are only occasionally parasitic.

Most parasites, except those which attack the skin, gain entrance to the body with food or drink; sometimes from eating with soiled fingers; the eggs or larvæ being thus swallowed.

Those which attack the skin are communicated by contact, or dirty clothes, or even carried through the air, and they are encouraged by dirty habits. Debility predisposes to the attacks of parasites of all kinds.

The prevalence of parasitic disease is therefore certain evidence of bad sanitation. If water and food be uncontaminated and healthy, and if person, clothes and surroundings be kept clean, parasitic diseases cannot occur.

Parasites have been divided into *ectozoa*, or those which affect the exterior of the body, and *entozoa*, or those which affect its interior.

Besides the occasional parasites already mentioned, *ectozoa* comprise lice, itch acari, and minute acari (*demodex*) which inhabit sebaceous follicles in the skin.

The following is a list of the most important *entozoa* which affect man in India and the means by which they enter the body *:—

1. *Trematoda* (*Flukes*).

   Fasciola hepatica and various species of *Distoma*. These are rare in man, but common in fish, sheep, and cattle; fish are believed to be their natural habitat. Source: undercooked flesh and contaminated water.

---

* This list is taken, with some alteration and addition from Cobbold.

2. *Cestoda* (*Tape-worms*). (4)
   - *Tænia medio-canellata*, from insufficiently cooked "measly" beef, which contains its larvæ (cysticerci). Similarly *Taenia Solium* from badly cooked pork and *Bothriocephalus latus* from fish. (This worm is as yet unknown in India.)
   - *Echinococcus hominis* (*hydatid* or *bladder-worm*), from the excrement of dogs affected with *taenia echinococcus* or from water to which such dogs have access, probably also from jackals.
3. *Nematoda* (*Round-worms*). (7)
   - *Trichina spiralis*, from insufficiently cooked flesh of pigs affected with it. It has not been recorded in Indian pigs.
   - *Trichocephalus dispar*, from contaminated water containing its eggs.
   - *Filaria sanguinis* (*Blood-worm*), from impure water containing its larvæ, which are sucked from the blood of affected men by mosquitoes and by them carried to water (*vide* remarks further on).
   - *Dochmius duodenalis* (*anchylostoma duodenale*), from contaminated water containing its eggs. This worm is exceedingly common in many parts of India and in Assam.
   - *Filaria medinensis* (*Guinea-worm*), from infected water. It is still a debated question whether it enters through the skin while bathing or in drinking-water.
   - *Oxyuris vermicularis* (*Thread-worm*), from eggs swallowed in contaminated water or food. Dirty children probably re-infect themselves and infect one another.
   - *Ascaris lumbricoides* (*Round-worm*), same as *Ascaris suilla* of pig. Acquired from contaminated water or soiled vegetables which contain its eggs.

PREVENTION OF PARASITIC DISEASES.

The methods to be adopted for the prevention of these diseases are simple and obvious.

The lodgment of *ectozoa*, such as itch acari and lice, may be prevented by cleanliness of person and clothing and avoidance of contact with affected individuals. Clean dwellings ought to be free from fleas, bugs, and ticks; but it should be noted that fleas and ticks are apt to be introduced by domestic animals. The skin diseases due to the growth of parasitic fungi on and in the skin, which are so common amongst the poorer classes in India, can be prevented by due attention to cleanliness both of person and of clothes. Great care is now being taken at Indian ports which are used by vessels coming from Africa to prevent the introduction into India of "Pulex Penetrans" or the *jigger flea* which has overrun Africa of recent years. The female of this flea bores beneath the skin of men and excites serious inflammation.

Entozoa are most commonly acquired by drinking polluted water containing their eggs or larval forms. Their eggs may also be conveyed on vegetables or fingers soiled with excrement containing them. Tape-worms are acquired by eating the under-cooked flesh of animals containing their larval forms; thorough cooking kills these. Trichina is acquired in the same way. An uncontaminable water-supply is the first essential for the prevention of all these parasites. All water which is not above suspicion should be well boiled to kill their ova or larvæ. Doubtful vegetables should be cooked, and suspected meat also, if eaten, should be well cooked.

The evacuations of persons affected with intestinal parasites should be burnt or buried deeply. Water polluted with such evacuations containing ova is the most fertile means of propagation of these parasites. Animals may also be infected by eating the excrement or grass which is soiled by it, and man by eating vegetables manured with it. It may be useful here to give a little further information concerning some of the most common parasites with a view to measures for their prevention.

Lice in clothes may be destroyed by boiling. On the body it must be remembered that they leave their eggs attached to hairs; and, though the lice may be destroyed by mercurial ointment or otherwise, the eggs are hatched and give rise to a new brood at the end of five or six days.* Any vermicide used must therefore be applied continuously for a week. The simplest and surest way to free the head is to shave off all the hair and burn it.

---

* Lice are hatched at the end of 5 or 6 days and reproduce at the end of 18.—*Van Beneden.*

Itch is caused by the burrowing of a minute *acarus* in the skin. It may be seen with the aid of a lens, and is not uncommonly found in clothes. To prevent its recurrence the application of sulphur, or whatever other remedy is used, must be continued for a considerable length of time in order to destroy the young acari as they are hatched from the eggs which are left in the skin.

Tape-worm is common in parts of Northern India, but rare in Madras. The beef tape-worm can obviously affect only Muhammadans, Christians, and other beef-eaters. Its life history is as follows: Water is polluted with the excrement of men affected with the tape-worm, and its eggs thus pass into the water (one worm produces some 50,000 eggs). Cattle drink this water, the eggs are hatched in their bodies, and the larval or immature worms burrow into their flesh where they are known as *cysticerci* or bladder-worms.* These may be destroyed by very thorough cooking; but, if not so destroyed in flesh which is eaten by men, they become developed in the intestines into complete tape-worms.

An immense number of other species of tape-worm is found in various animals, but few of them are communicable to man.

Hydatids or cystic disease, caused by the larvæ of a tape-worm (tænia echinococcus) which affects the dog and jackal, are occasionally found in men, but are more common in cattle, all over India.† Access of dogs to drinking water intended for man should therefore be prevented.‡

Filaria Sanguinis or blood-worm. Embryos of this worm are found in the blood of persons affected with elephantiasis, lymph scrotum, and chyluria; and in districts where this disease is prevalent embryos are found in the blood of a considerable percentage of otherwise healthy persons. The adult worms live in the lymphatic vessels. The female, a hair-like worm 3 inches long, is viviparous and may live for years in a man without causing inconvenience to her host so long as she discharges only developed embryo-worms which pass through the lymph-glands into his blood. Manson's theory is that she occasionally aborts and discharges ova instead of embryos into the lymph stream. These being too large to pass the lymph glands stick fast and cause obstruction: the condition known as elephantiasis follows. When mosquitoes feed on a person whose blood contains embryos, they suck out some of these with the blood. In certain species of mosquitoes the embryos are able to undergo further development. Manson's original idea was that the mosquitoes containing the embryos flew to water to lay their eggs and died there, and that the embryos set free in the water found their way again into human beings when the water was used for drinking. Later observations have shown that the embryos find their way into the proboscis of the affected mosquito and it is therefore possible that they may obtain entrance into the human body while the mosquito is in the act of biting. Whatever its exact method of spreading, the fact remains that the disease is a very local one: even in towns some quarters are badly affected, while others are free. Improved drainage and water-supply tend gradually to eradicate it.

---

* "Sometimes as much as 14 per cent. of horned cattle slaughtered at Rawal Pindi are affected with cystic disease."—*Report of Indian Cattle Plague Commission*, 1871.

† A case of hydatid of the brain has lately been recorded by Surgeon Armstrong in the Madras Lunatic Asylum.

‡ In connection with this point it may be of interest to note that dog's excrement is not uncommonly employed by native quacks as a medicine!

Dochmius duodenalis (*Anchylostoma*).—This small worm inhabits the upper part of the intestine. It had been previously known in Egypt and was first found in India by Dr. McConnell of Calcutta. It was noticed in Madras in 1883 in a case sent to the Chemical Examiner from South Arcot. Many cases are now annually admitted into the General Hospital, Madras. It appears to be transmitted usually by eggs in polluted water, in the same way as the common round-worm. It causes anæmia which may end fatally. Recent investigations have shown that the embryos live for some time in mud polluted with fæcal matter, and may be transferred to the mouth if food is eaten with hands soiled with this mud. It is also possible that the embryos may on occasion gain access to the body by boring through the skin.

Round-worm (*Ascaris lumbricoides*).—This is the commonest of all intestinal parasites in India, and it is found in every part of the world. Its local prevalence has been investigated in England, and it was found to be most common in places where the water was polluted. Its extraordinary prevalence all over India is no doubt connected with the widespread fæcal pollution of drinking-water which prevails everywhere. In India it is exceptional to find an individual who does not harbour some of these parasites!

Guinea-worm is endemic in many places. It takes about a year to mature after its entrance into the body. The point is not yet settled as to whether it enters in drinking-water or through the skin in bathing. H. V. Carter supports the latter view, and the author's limited experience is also in favor of it.* The milky juice which exudes from the mature worm contains myriads of embryonic worms.

Improvement of water-supply brings about a disappearance of this parasite. Thirty years ago it used to be fairly common in Madras City, but during the past five years not a single case has been heard of which had its origin in the city: the few cases that seek admission to the hospitals have been infected elsewhere, *e.g.*, in Bellary or Cuddapah districts.

Bilharzia hæmatobia is allied to the flukes. It obtains entrance to the body in contaminated water perhaps encysted in a minute crustacean. Its range was supposed to be confined to Africa, but now it appears to be also found in the West Indies and South America. Several cases have recently been imported into India and recognized in Bombay and Madras, so it is possible that the worm may establish itself somewhere. The ova leave the human body in the urine and fæces, and hæmaturia is a constant symptom.

---

* In 1873-74 when he was in charge of the 3rd Madras Light Infantry at Secunderabad, guinea-worm became very prevalent in the regiment. He noticed that it occurred mostly, if not exclusively, among men who bathed in a certain tank. On the use of this tank being prohibited, the disease disappeared. On one occasion he removed from under the skin of a patient a half-grown pink colored guinea-worm—Vide *Indian Annals, Mad. Sci.*, 1874.

CHAPTER X.

MICROBIC DISEASES.

The word microbe is conveniently used to indicate any form of microscopic life whether animal or vegetable in nature, and is synonymous with, though shorter than, micro-organism, and it is in this sense that it will be employed in these pages. Coccus, bacillus, and similar terms have a definite and much more restricted meaning to which they will each be confined. The microbes which cause disease—pathogenic microbes—are true parasites and the reasons why they are considered in a separate chapter are mainly those of convenience coupled with certain differences in their mode of life.

They find entrance to the body (1) by inoculation through a wound of the skin or mucous membrane, though sometimes application to an unbroken mucous membrane is sufficient, (2) by inhalation into the air passages, (3) by the mouth with water or food. Sometimes a microbe can enter by one of these ways only, sometimes by all, but, having entered, symptoms of diseases do not begin at once ; there is a period of *incubation* during which the microbe multiplies enormously and spreads. Then the symptoms of the disease declare themselves, last a certain time, and finally the sufferer dies or recovers. In the body the microbes act by producing local irritation or destruction of tissues or blocking of vessels, or by producing substances which act as chemical poisons on the tissues of the patients. Recovery shows that the susceptibility of the person for the time being has disappeared, and is due either to the exhaustion of the particular material on which the microbe flourished in the body, or to the formation of substances by the microbe in the body which prevent its further growth, or to the powers of defence of the body being able to destroy the microbes and neutralise their poisons. After recovery from such an attack, it is often the case, but not always, that the individual is insusceptible to another invasion by the same microbe for a longer or shorter period, perhaps for life.

Several of these diseases, such as tuberculosis, anthrax, rabies, are common to man and lower animals, and may be transmitted from one to the other.

The most important common characters of microbic diseases are the following: each of these diseases is due to a specific micro-organism, and therefore each case of such disease can only be originated, directly or mediately, from a previous case of the same disease*; the organisms which cause these diseases are capable of indefinite multiplication under favourable circumstances, within the body or external to it, and often are multiplied to an enormous extent in the bodies of affected individuals; many microbes show a preference for particular organs or tissues and for particular individuals or races (in the same way that larger plants show preferences for particular soils); there is a period of latency or incubation between the time of reception of disease-producing microbes in the body and the first symptoms of disease (being the period required for germination and multiplication of the organisms); many microbic diseases run a definite and limited course and, in such cases, one attack usually protects against further attacks of the same disease.

The analogy of microbes with larger plants is obvious.† Seeds sown in fertile soil remain latent for a definite period, but eventually give birth to a crop of plants which run a certain course of life and multiply the original seed many fold. Each plant can only be propagated from the specific seed of a similar plant: rice seeds will only produce rice-plants, and small-pox seeds will only produce small-pox.

Plants of the same specific nature may, however, exhibit differences of vigor and variations, depending upon differences of soil, season, or other conditions. Differences of activity and character in the same disease in different climates or among different races, or in different epidemics, may be similarly explained—indeed by artificial cultivation under certain conditions, or by growth in certain species of animals, some known disease-germs may be modified so as to have their virulence increased or diminished.

---

* This is the commonly accepted doctrine, but it cannot be considered logically proved until it is shown that innocent microbes may not, under certain conditions, become disease-producing, and there is some support for the opinion that they may.

† This analogy may be so unmistakably traced in the clinical course and general history of many diseases in which specific microbes have not been fully demonstrated that such diseases are now generally regarded as microbic. On sanitary grounds, as already explained, it is most desirable that they should be so regarded.

Modifications of breed occur very much more rapidly in microbes than in large plants, because the former go through very many generations in the time occupied by one of the latter.

Forms and Characters of Microbes.

The study of microbes has been followed (1) by observing their microscopic appearances, including their mode of propagation and development and the changes which they undergo in varying conditions of natural growth or artificial cultivation, and the peculiarities they exhibit in staining with certain dyes; (2) by observation of the physical characters (such as color and shape of mass) of their growth in masses or crops when cultivated artificially; (3) by examination of the chemical changes which they produce in the material in which they grow; and (4) by observation of the diseases which are produced by some of them.

Bacteria.—The vast majority of disease-microbes hitherto discovered belong to an order of extremely minute organisms of apparently very simple structure termed *Bacteria* or *Schizomycetes* (fission-fungi), the latter name indicating that they multiply by division, each half becoming a separate organism. Some species may multiply in this way with extraordinary rapidity. Bacteria have been classed, according to shape,* into (1) spherical or ovoid bacteria (*micrococci*); (2) short rods (*microbacteria*); (3) long rods (*bacilli*); and (4) spiral rods (*spirilla*). Many bacteria are motionless, but some are *motile* and exhibit very lively movements caused by rapid lashing of one or more extremely fine whip-like processes (*flagella*). Bacteria comprise a large variety of species and are widely diffused in nature, being found almost everywhere in more or less abundance. Some species resemble each other so closely in appearance and size that it is scarcely possible by microscopic examination alone to distinguish them from one another. If we can imagine large plants to be reduced to the minute size of bacteria, it would be equally difficult to distinguish many which we know are specifically distinct.

---

* By Cohn.

The conditions necessary for the growth of bacteria are (1) nitrogenous material suitable for their nourishment, (2) moisture and (3) a certain temperature (varying with species and acclimatized variety of bacterium). Some also require the presence of air. Spirilla grow only in liquid or semi-liquid substances. Different species of bacteria grow with different facility in various substances. Dead organic materials are their favourite soil, and the growth of microbes is the cause of decay and putrefaction ; but, as we see in disease-producing species, some may grow in the living tissues of animals or plants, especially when such tissues are deficient in their inherent vitality. Bacteria grow best in an alkaline medium and moulds in an acid medium. As a rule therefore bacteria are the parasites of the animal kingdom since the tissues and fluids of animal bodies are alkaline, and moulds are the parasites of the vegetable kingdom since the juices of plants are acid.

Spores.—Most species of bacteria are capable, under some circumstances, of forming seeds or spores—extremely minute bodies—which retain their vitality for an indefinite time and when exposed to some conditions (such as drying or exposure to a temperature below that of boiling water) which would kill mature bacteria. Spores in favourable surroundings bud out into bacteria.

Other orders of Fungi also furnish some disease-producing species: a *Saccharomyces* (yeast or sprouting fungi) is the cause of "thrush ;" *Hyphomycetes* (moulds) cause several skin diseases, and some of them have, in rare cases, invaded internal organs ; *Actinomyces* causes a peculiar disease in cattle and man ; *Mycetoma* or Madura foot is due to invasion of the tissues by a similar organism.

Innocent and Pathogenic Microbes.

To prove beyond all doubt that a certain disease is caused by a certain microbe, the following conditions * must be satisfied : (1) the microbes must be found in the blood or diseased tissues in all cases of the disease ; (2) the microbes must be isolated and be artificially cultivated for several generations outside the body ; (3) on introduction of the microbes so cultivated into the body of a susceptible animal the same disease must be produced; (4) the microbes must be found in the blood or diseased tissues of the animal so inoculated.

---

* Usually known as Koch's postulates.

All these conditions have been complied with in the case of several diseases of men and animals; but such complete experimental proof is rarely possible, because, in some cases, of failure to cultivate the organisms outside the body, and, in other cases, of the impossibility of finding animals which are susceptible to the particular disease, and experiments of this kind cannot be performed on men.*

It is generally considered that if a certain microbe be constantly found in the blood or diseased tissues in cases of a given disease and not otherwise, the evidence that such microbe is the cause of that disease is all but conclusive, especially if the disease be proved to be communicable.

The term "pathogenic" (disease-producing) is generally restricted to those microbes which produce specific forms of disease when they grow within the body. Many of these microbes are very selective and exclusive as to the soil in which they will grow; they often require very complex organic substances for their nutrition and restrict themselves to particular genera or even to single species of animals and sometimes to certain tissues only. Hence it is often difficult to cultivate some of them outside the living body. Their most important character is the power which they possess of growing in the tissues of healthy animals and producing, it may be, dangerous or deadly diseases in their hosts.

It is probable that many, if not all, pathogenic microbes may, under favourable conditions, grow outside the body. The anthrax bacillus is known to grow readily thus in damp soil or on decaying organic substances. Koch found his cholera bacillus in the water of a foul tank at Calcutta, and the enteric bacillus has frequently been found in contaminated water which had given rise to enteric fever. But as yet our knowledge is very scanty regarding the life history of disease-microbes growing outside of the body. The geographical localization (endemicity) and seasonal prevalence of microbic diseases, that is, their being so much influenced by external conditions, are facts which somewhat favour the view that their specific microbes grow apart from as well as within the body.

---

* It has often been proposed, but rarely permitted by any Government, that such experiments should be allowed on condemned criminals. There is nothing inhuman or improper in such a proposal. Men who had grievously injured their fellow beings would most fitly expiate their crimes by rendering such services to all humanity.

Innocent or non-pathogenic microbes are found in immense variety and numbers in all decomposing organic substances; and different species often succeed each other in crops at various stages of decomposition, according as the particular kind of nourishing material which each prefers becomes exhausted. Organisms of this kind are always found in the nose, mouth and intestines of animals, without producing injurious effects. If introduced into the healthy tissues or blood of living animals, they are speedily destroyed.

Ordinarily innocent microbes may, however, produce disease (though not specific communicable disease) in three ways: (1) they may produce poisonous alkaloids or extractives in decomposing articles of food; (2) they may cause decomposition of ingested food in the alimentary canal with local irritation and perhaps absorption of poisonous products; (3) they may grow in the discharges of wounds or ulcers, in abscesses, and in dead or dying portions of tissue, the decomposition-products produced by them causing local irritation or general poisoning.

Susceptibility and Immunity.

Seed will not grow unless it be sown in suitable soil. It is a matter of common observation that large plants show preferences for particular kinds of soil and particular climates. Microbes show similar preferences, but many of them, especially pathogenic species, are more exclusively selective than larger plants in this respect. Thus some disease-microbes confine their attacks to one species of animal, for instance those of leprosy and cholera attack man only; while others, such as those of anthrax, not only attack animals of different species, but are known to grow very readily outside the body. The electiveness of microbes for particular soils is shown by the preference which some of them * show not only for a particular species of animal but for a particular race or variety of one species and for particular individuals.

---

* Measles, for instance, which is a mild disease in Hindus, more severe in Englishmen, and which has been terribly fatal among the Fijians.

Immunity is that condition of the body which renders it able to successfully ward off the attacks of pathogenic microbes and to neutralise their poisons. Persons may be born immune against certain diseases or they may acquire immunity during their lifetime. Immunity is however a relative state and depends largely on the health of the subject at the time he is exposed to infection and also on the dose of the poison he receives. Experiments show that animals are able to successfully combat certain quantities of bacterial poisons, but that certain larger doses are beyond their powers of resistance and cause death. Natural immunity is a property of the body to which it belongs and cannot be removed from it with its blood. Immunity may be acquired by passing through an attack of the disease or by having the resisting power of the body increased by injections of small doses of the specific poison which cause the tissues to produce substances antagonistic to the growth of that particular organism. The poisons formed by microbes in their growth are called toxins, and these are sometimes sufficiently powerful to kill without the assistance of the microbes themselves. The substances produced by the tissues which antagonise the toxins of a bacillus are called antitoxins. These are present in the blood and can be withdrawn with the blood from the body. The serum obtained in this way can be used as a curative agent for neutralising the toxins in the blood of a person suffering from the same disease. Pathogenic bacteria vary considerably at times and in places in their virulence or power to cause injury. They are particularly apt to lose their virulence when artificially cultivated outside the body, since the conditions then are not quite natural. Variations in the susceptibility of individuals taken together with variations in the virulency of the particular bacilli with which they become infected account for the differences noticed in the severity of the attacks of any disease.

Contagion.

Diseases which are capable of transmission from man to man whether immediately by direct contact or mediately through the air, by infected clothes, or by water or food, must be due to the passage of infective material from person to person. The actual infective matter is known by the term *contagium*. *Contagion* denotes the process by which the contagium is conveyed from person to person. The distinction between the once widely used terms *infectious* and *contagious* has been lost, and their use is therefore better avoided, those diseases which are due to a contagium being classed together as *communicable diseases.* In every case the contagium is a specific living organism capable under favourable conditions of multiplying itself enormously. Sometimes disease is caused by the multiplication of the organism at the point of its entrance into the body and the elaboration of powerful poisons or toxins, which are absorbed and give rise to the symptoms of the disease, *e.g.*, tetanus in man, sometimes the organisms produce only feeble toxins, but themselves rapidly invade the whole body, *e.g.*, anthrax in horses. The specific contagia (microbes) leave the body by various channels. In those communicable diseases which are characterised by a skin eruption the contagium is present in the dry scales which leave the surface of the body. Particles of this matter float about in the air and convey the infection, *e.g.*, measles and small-pox.

In other cases bacilli are found in the matter coughed up from the lungs, as in phthisis and pneumonia. In diseases affecting principally the intestines the specific organisms are found in the fæces and urine, as in cholera and enteric fever. After leaving the infected person the microbes may at once obtain entrance into a healthy one, more frequently they have to survive for varying periods outside the body before re-introduction.

Ordinarily contagia do not survive long in the air. Dryness, want of nourishment, light and oxygen all combine to destroy them, and diseases can only be propagated through the air for limited distances. It must be remembered too that the contagium is particulate matter, though very minute, and gradually settles down owing to gravity.

Organisms which are capable of forming spores stand a much better chance of survival in unsuitable media than those which do not, since the spores will resist desiccation and heat to a far greater degree than the organism itself. Many of the pathogenic bacteria are not known to spore.

In water pathogenic microbes may survive and even multiply freely under certain conditions, and similarly in the soil. Owing to the difficulty in isolating any species of bacillus when mixed up with thousands of others in water and earth, it is not yet possible to say how long pathogenic organisms will survive under different circumstances in earth and water, but at times the limit may certainly be measured in months. Again it is not yet clear whether soil and water are to be looked upon as the natural resting place of certain of the contagia, from which they from time to time arise and invade men and animals, or not.

It must not be forgotten that contagion is possible through the medium of both domestic animals and men, who are not themselves affected by the disease.

The part played by flies and other insects as passive agents in the spread of disease can by no means be overlooked; some insects such as mosquitoes and ticks sometimes take an active part by acting as the intermediate hosts of the parasite.*

It is certain that flies may carry contagion. In the famine-camps in 1877 ophthalmia was so disseminated by them that hardly a child escaped. It is probable that they often propagate small-pox.

Acute communicable diseases such as small-pox or dengue are easily propagated and the infective agent rapidly causes the typical diseased state. Groups of individuals are therefore affected, each case acting as a focus round which other cases occur. Such diseases are commonly epidemic and their communicable character is evident to all. Chronic communicable diseases, on the other hand, such as tubercle or leprosy, are not so easily propagated and the symptoms develop very slowly in the newly infected person so that the cases appear to have less connection one with another and their communicable character is not so obvious.

---

* All flies pass through the following stages of development :—

(1) Ovum or egg.
(2) Larva.
(3) Pupa.
(4) Imago or fully developed fly.

The common fly lays about 120 eggs in some mass of decaying organic matter. These hatch in about 8 hours and the larval stage lasts about 3 days during which the larvæ feed greedily and grow rapidly. They then change into pupæ, this being a resting stage lasting 4 or 5 days during which no food is consumed. Finally the adult fly emerges from the pupa. The whole cycle is thus completed in less than 10 days, so that in a month a single female can produce over a million descendants. It should be noted that flies cannot multiply in the absence of organic matter on which their larvæ can feed. A plague of flies, therefore, points to faulty sanitation and imperfect disposal of refuse, and is likely to be speedily followed by epidemic disease to the spread of which the flies contribute by carrying about infective matter on their feet.

The *dose* of a contagium would theoretically appear to be a matter of little importance, since even one single microbe may multiply indefinitely. Practically, however, it has been found in some cases that a small dose inoculated produces only a local affection, a larger dose being required to produce the general disease. A large dose of weak or attenuated virus is also required to produce the same effect as a small dose of strong virus. The weaker effect of a small than of a large dose may be due to the slower multiplication of the microbes, the parent microbes being fewer, and perhaps to some enfeeblement of the brood in its struggle to obtain a footing in the body. If a community has been free from any communicable disease for a prolonged period and that disease is again introduced, it affects the people much more severely than it was wont to do in former days both in point of numbers attacked and in mortality. It seems therefore that immunity tends to disappear. If a disease is more or less continuously prevalent there must always be a considerable proportion of the population protected and severe outbreaks consequently are not so likely to occur.

Endemics and Epidemics.

A disease which occurs at intervals in isolated cases is said to be *sporadic*; when it is always more or less prevalent in a place or community, it is said to be *endemic*; when it becomes largely prevalent for a time where it previously did not prevail, it is said to be *epidemic*; and when an epidemic is very widespread over a large tract or over the whole earth, it is said to be *pandemic*. Microbic diseases are nearly always endemic or epidemic in their incidence; this is a natural consequence of their communicable nature.

alaria
holera
fluenza

The presence of endemic disease implies constant local conditions which favour it. The presence of epidemic disease implies at least the temporary existence of such conditions and the importation of the specific virus of the disease, unless it was already present.

What the local conditions are which favour the existence of endemics and epidemics, and how they may be mitigated or removed, it is the practical business of the sanitarian to examine.*

---

* For such inquiries an intimate knowledge of medicine, a just appreciation of the causes of disease, keen power of observation, and some logical acumen are desirable. Many reports of inquiries, by able officers, published in the Reports of the Medical Officer to the Privy Council and Local Government Board (England) may be taken as models for investigations of this kind.

In the case of epidemics, moreover, where the disease did not already exist, it will be necessary to inquire into the methods of importation and spread. The first cases which occur are most likely to afford a clue, and no trouble should be spared in obtaining all possible information regarding them. Local insanitary conditions undoubtedly favour the spread of epidemics, and our first care should be to remove or mitigate them—we may thus prevent a disease from settling even if it be imported—but our second care, especially if local conditions are bad, should be directed towards preventing its importation and isolating cases which occur.

The origin of epidemics of microbic disease is still in great part a matter of speculation. Why do diseases which are endemic or sporadic sometimes exhibit an increase of virulence and a tendency to spread and assume the epidemic form? Why do epidemics spread from certain centres in a wave-like manner, being most severe and fatal at their first onset and gradually diminishing in intensity until they become extinct, except in endemic foci where they slumber? The starting point of epidemics has been attributed, with apparent probability, to the origin under favouring conditions of a brood of specific microbes possessing unusual vitality and virulence. Accidental hardy varieties in plants and unusually vigorous breeds of animals arise occasionally in an analogous way. Swarms of locusts or moths or other insects come into being when conditions have been peculiarly favourable for their development, but not otherwise. The conditions which give origin to epidemic "sports" in disease-microbes are unknown; but the marked effect which climatic conditions have been observed to produce upon epidemic diseases points to the probability of such variations occurring during the growth of the microbes outside the body. The greater intensity of an epidemic at its onset, and its gradual decline and extinction, are usually explained by the theory that the most susceptible individuals are first attacked, and later on those who are less susceptible and who therefore do not suffer so severely, and that, finally, the soil being exhausted, the disease dies out. If this be true, the spread of an epidemic from a centre may be aptly compared to the growth of certain mushrooms in gradually widening circles ("fairy rings") according as they exhaust the soil of the nitrogenous nutriment which they require for their sustenance. It is probable that in areas where diseases are endemic either the soil or the water or both form the natural habitat of the specific microbes, In epidemic areas, on the other hand, into which a disease is imported and where it does not permanently establish itself, the contagium exists principally in the bodies of the infected individuals; if the soil and water become infected, they retain the infection only temporarily, as it tends to die out when its location is not suitable. Koch suggested that cholera microbes may ordinarily grow among decaying vegetation in such places as the Sunderbunds, and thence invade man. Although cholera has frequently been imported into Western Europe, it has never succeeded in permanently localising itself there.

Epidemics sometimes appear to arise spontaneously, that is, no importation can be traced. This may commonly be owing to imperfect information, but it may occasionally be due to latent foci of the disease existing in a place. It is possible that the specific microbes or their spores may have existed locally in a dormant condition, or at all events without invading the human body.

Epidemic diseases may be imported over and over again into a place; but, if local conditions be unfavourable, they will not extend.*

Man can usually do little to alter climatic conditions, but he may often do much to alter other local conditions. He may keep the surroundings and interior of his dwellings clean and dry, thus arresting the local propagation of microbes; he may preserve his water and his food from defilement; he may strengthen his own body, so that it shall not be a ready prey for microbic invasion; he may isolate cases of disease and destroy the germs produced by them.

Epizootic Diseases.

Domestic and wild animals suffer from communicable diseases which at times are transferred to human beings, and similar precautions have to be taken to prevent their spread, not only to avoid loss from the death of valuable beasts but also to secure the safety of men. Amongst these epizootic diseases are anthrax, tuberculosis, rabies, foot-and-mouth disease or epizootic aphtha, actinomycosis, glanders and plague.

---

* This was the well-known view as to the influence of climatic conditions on the spread of cholera held by the late Dr. Bryden of Calcutta.

PREVENTION OF MICROBIC DISEASES.

Effective measures for the prevention of microbic diseases act—(1) by depriving the virus of a soil suitable for its growth, (2) by excluding it, or (3) by destroying it. Under the first head, we shall notice the removal of conditions which favour the growth of microbes without and within the body, and protection by inoculation; under the second, the isolation of the sick; and under the third, the use of disinfection.

External Conditions which favour Microbic Growth.

These have already been alluded to when treating of soil, houses, removal of refuse, water, food, &c. Climatic conditions, such as moisture, warmth, and stillness of air, are to a great extent unavoidable; but in climates where such conditions prevail, it is particularly necessary to pay great attention to dryness and purity of soil about houses, to cleanliness and free ventilation within them, and to the speedy removal of all waste matters and their disposal in the fields, where they may be disintegrated by harmless microbes and be assimilated as plant-food. As previously mentioned, little is known regarding the external life of such disease-microbes as may live apart from the body; but it is certain that some may live apart, and, in the absence of definite knowledge, it is safest to assume that others may likewise, and to take all possible measures to discourage such growth.

Bodily Conditions which favour Microbic Growth.

Feeble vitality of the living tissues undoubtedly predisposes to the invasion of microbes. Even ordinary septic microbes may attack tissues which are dying or whose vitality is at a very low ebb. Previous good health and strong vitality do not, however, afford much resistance against the attacks of all pathogenic microbes, except by preventing their lodgment in the body. If the skin and mucous lining of the respiratory and digestive tracts be in a healthy and unbroken condition, most disease-microbes may be brought into contact with them over and over again without being able to effect a lodgment. On the other hand, a scratch or ulceration of the skin, in a previously healthy individual, may admit the microbes of many diseases, such as syphilis, tetanus, &c. Ulcerated conditions of the intestinal mucous membrane, such as are extremely common in India, produced by intestinal parasites or otherwise, may also admit various microbes * into the blood or tissues.

Inflammatory conditions of the respiratory mucous membrane, or inactivity of respiration due to deficient exercise or previous disease, may prevent the inhaled microbes of tubercle, pneumonia, &c., from being thrown off. There is some evidence that chemical alteration of the normal secretions, or of the blood or tissues, may dispose to microbic infection,† and there is no doubt that inherited weaknesses of certain organs may do so.

It is thus apparent that physiologically morbid states do predispose to the reception of microbic diseases, and thus preservation of the general health is one of the best safeguards against them.

Protection by Inoculation.

Protective inoculation is an attempt to assist the tissues of the body in resisting the invasions of pathogenic microbes. Sometimes the chief effort must be made against the microbes themselves, sometimes against their toxins. As mentioned before, if a person has passed through an attack of a specific disease his tissues have usually acquired the power of destroying the specific microbes of that disease if at a future time they enter his body. This is naturally acquired immunity. If it be desired to confer immunity artificially, to render the tissues antimicrobic, this may be done by inoculating the person with successive doses of the specific microbe, beginning with dead ones, or ones that are attenuated, that is, have had their virulence reduced, and proceeding to stronger doses of the fully virulent organism, until the subject can bear with impunity the introduction of a dose of the microbes into his system which would infallibly have killed him had he not been immunised by the previous inoculations. The tissues of such a person have become actively antagonistic to that particular microbe and remain so for a varying length of time, during which he is not susceptible to an attack of the disease of which it is the causative agent. Haffkine's anticholera and Wright's antityphoid injections were made on this principle. A less complete and less durable protection can be afforded by the injection of only the toxins of the microbe which have been obtained by cultivating it in fluid media outside the body. The injected toxins stimulate the tissues to form antitoxic substances which remain available for neutralising the toxins formed in the case of a subsequent accidental infection with the disease in question, but no antimicrobic substances are formed as microbes are not injected. Haffkine's plague prophylactic is obtained by a combination of these two methods. It contains the toxins of the plague bacillus formed during its cultivation in a fluid broth for six weeks, together with the dead bodies of the bacilli themselves.

---

* Including *actinomyces* and even *mycelial fungi.*

† For instance Koch found that his cholera bacilli were destroyed by the naturally acid gastric juice but passed through the stomach unaffected when its contents were neutral or alkaline.

Doubtless before long great progress will be made in the direction of similar protective inoculations, but success appears to be at present curtailed by the fact that there are many different varieties of each pathogenic microbe, each of which has its own special action in the body and each of which forms toxins slightly different from those formed by other varieties or races; with the result that the protection conferred by the use of one variety or one toxin is not absolute when infection with another variety occurs, which produces a toxin which cannot be entirely fixed by the antitoxin elaborated by the tissues in response to the injections with the first variety.

Pasteur's antirabic injections * are based on the same idea of injecting increasingly strong doses of the poison to stimulate the tissues to produce antitoxin. In this case, however, the curative injections are not practised till after a person has been bitten by a rabid animal. The incubation period of rabies is generally sufficiently long to allow the injections to take effect before the disease has declared itself. One or other of these methods is now being employed in the protection of cattle from certain epizootic diseases.

Another way of conferring protection is by inoculating the virus of the disease after it has been modified and lessened in virulence by passage through an animal. This is done in the case of small-pox. The contagium of small-pox is profoundly modified by passage through a calf, but when subsequently inoculated into a human being it gives as good protection as results from a previous attack of small-pox itself. This process is always styled "vaccination."

---

* Now carried on in India at the Pasteur Institute, Kasauli.

Inoculation of small-pox directly from person to person has been freely practised in past times in many countries, and it still goes on in certain parts of India and in Burma. The idea is that inoculation from a mild case of small-pox will only result in a mild case of small-pox which will protect from possibly severe attacks in the future. Unhappily this expectation is not always realised, for sometimes death follows the inoculation. The practice is now forbidden by law everywhere, not only because death may follow, but because cases of the disease are actually multiplied and so many fresh foci for starting an epidemic are brought into existence.

The practical application of protective inoculation is greatest in the case of small-pox, which is a world-wide, easily-spread and dangerous disease. Nowhere is a person safe from possible infection, and no means of protection is available but vaccination. The other diseases are less widely distributed and less easily communicated, and other ordinary precautions may be sufficient to guard a man. Hence inoculation is only resorted to in times of severe epidemics when whole towns are exposed equally to the risk of infection, as in plague; or when a man is going to a district where some disease is prevailing, *e.g.*, typhoid fever; or after actual infection, as in rabies.

Isolation of the Sick.

The advantage of limiting a communicable disease by isolating persons suffering from it is obvious and has been recognised from ancient times. But isolation is not equally useful or practicable in all cases of communicable disease; and the manner and degree in which different microbic diseases are communicable must be taken into account in devising measures for their limitation. Some like small-pox, whooping-cough, dengue and mumps, are easily and usually communicated, for some distance, through the air, as well as by contact of persons or infected articles. A second group, containing diseases such as tuberculosis and pneumonia, appears to be less readily communicable. A third group, comprising cholera and enteric fever, is communicable rarely, if ever, through air, but usually in drinking-water and probably in food; while a fourth group of diseases, such as syphilis, rabies and probably leprosy, appears to be communicable only by inoculation. Malaria stands by itself, as it is only communicable from person to person through the intervention of the mosquito.*

It is in the case of the first of these groups, which contains what are commonly known as "infectious diseases," that isolation is particularly efficacious and desirable. It is so to a lesser degree in the second group. In the third group, other measures, such as disinfection, cleanliness and preservation of water and food from infection, are most useful, isolation being unnecessary if they are strictly attended to. In the fourth group isolation is useful; but, owing to the chronic nature of some inoculable diseases, it may be difficult or impracticable to enforce it. Individuals may generally, however, protect themselves from such diseases by avoidance of direct contact with the affected, especially of such contact as may lead to inoculation at any abraded or mucous surfaces.

It is evident, therefore, that isolation is most practicable and useful in those *acute* diseases which are ordinarily communicated by *aërial infection.* But the best manner of carrying out such isolation is not always apparent. Is all communication with sick persons and their households to be cut off? Are travelling and commerce by sea and land to be hampered or arrested by the restrictions of *quarantine?* Are the sick to be secluded, under medical care, in their own houses; or are they to be removed to special hospitals?

The first-named method of isolation by "boycotting" would, in most cases, be inhuman and barbarous, nor would it often be possible to carry it out effectively.

Quarantine, in the modern acceptation of the term, means arrest of communication with infected places except under certain restrictions. These usually consist in detaining healthy travellers for a specified time after their departure from an infected place, and travellers among whom the disease has broken out for a specified time after the occurrence of the last case of disease among them, on board ship or in a place (*lazaretto*) set apart for the purpose. The time of quarantine should cover at least the longest known period of incubation of the disease. Merchandise is also, if admitted, sometimes subjected to some process of disinfection, and the importation of particular articles, such as rags, may be prohibited.

---

* We allude here only to the habitual manner in which each disease is communicated—many diseases, as we have seen, being capable of communication in more than one way. Rare diseases produced by invasions of fungi which ordinarily grow outside the body may be classed separately.

In theory quarantine would seem to be an effective way of excluding communicable diseases; but actually it has nearly always failed to do so. It was practised extensively during the great epidemics which devastated Europe during the middle ages; but it signally failed to check them. It has, in more recent times, as constantly and conspicuously failed.*

The reasons for such failure are numerous. The period during which infection may last being much longer in some diseases and of more uncertain length than the period of incubation, persons among whom the disease has occurred, and possibly those who have been kept in contact with them, as the healthy are with the sick during ordinary quarantine, may carry infection for a longer period than can well be covered by quarantine. Quarantine usually interferes with food supplies, and it may thus cause privation and predisposition to disease; and by checking commerce it alters prices and affords strong temptation for its own evasion. The police or troops employed as quarantine guards cannot always be depended on; even if reliable it is difficult for them in all cases, impossible in most, to arrest all communication, and they themselves are exposed to hardship and are likely to contract and spread the disease.†

The imprisonment of healthy and sick together in a *lazaretto* is not only barbarous, but tends to keep the disease alive. Money is thus wasted on measures which are worse than useless when it might be usefully employed. These are some of the direct evils of quarantine. Indirectly its effect is equally pernicious: disease is concealed owing to the fear of quarantine; when it is imposed, the people, relying on the ostentatious measures taken for their security, encourage disease by neglecting local sanitation, and give way to panic when the epidemic breaks through their futile "sanitary cordon" of police and soldiers. Microbes must be met with other weapons than bayonets.

---

* The Sanitary Commissioner with the Government of India, alluding to quarantine, which was tried in 1872 in the hope of protecting certain cantonments from cholera, wrote: "in no single instance is there the smallest reason to believe that it was productive of any good." Quarantine restrictions "Set the people against everything that is done under the plea of their public health." "As a consequence cholera cases were concealed."

† Cholera was said to have been carried in this way in Egypt in 1883.

Land quarantine may therefore be regarded as impracticable, and least likely to be efficient in populous places, where presumably it is most needed. Sea quarantine may be useful in some cases if administered intelligently, but it scarcely concerns us here. In any case it should not be imposed for a longer period than the longest incubation time of the disease, after sailing from the last infected port or after the occurrence of the last case of the disease on board; and, for reasons given above, it should by no means supersede or dispense with the usual precautions of medical inspection.

Though quarantine, as such, is inadmissible, yet much may be done by individuals and by bodies, such as troops or students, subject to discipline, to avoid infection. Thus the public should be warned of the prevalence of communicable disease in particular localities, and persons under control may be prevented from visiting such places. When epidemic disease exists, movements and assemblages of population should, as far as possible, be restricted, and marches of troops, fairs, and pilgrimages be prohibited, or at all events carried out with special precautions, and schools may be closed with advantage in some cases.

A modified system of quarantine, especially in countries such as India, is not only justifiable but is of the utmost value when combined with an efficient system of observation, and it can equally well be applied on a land frontier, a sea board, and within the limits of a country. Such a system is now imposed in India to control the spread of plague. It has been particularly carefully worked in the Madras Presidency with most satisfactory results. Briefly, it consists in making all arrivals from an infected district take out passports which bind them to present themselves for inspection daily for a period of 10 days. Persons who appear to be suffering from plague are at the same time detained and isolated, and beggars and loafers, who can give no address and who cannot be relied on to report themselves, are also liable to detention. If a passport-holder fails to report himself he can at once be hunted up and safely dealt with if found to be suffering from plague.

Though this system is by no means infallible still it affords a large measure of protection and is not disagreeable to the public, as may be gathered from the fact that it has been in force in Madras City for over four years, and that during that period only from 3 per cent. to 6 per cent. in different years of the passport-holders escaped observation.

A similar system of medical observation, combined with disinfection of ships, is carried on in England in connection with ships coming from infected ports or having cases of infectious disease on board.

When an infectious disease breaks out in an army or in a body of workmen or prisoners, it may occasionally be possible to resort to the plan of isolation by groups, such as is practised in the extirpation of cattle diseases. The body is sub-divided into a number of smaller groups, which are kept separate. When any of these groups have been free from the disease for a period equal to its longest incubation-time, they may be passed as safe and not likely to spread infection.

Compulsory Notification.

The most efficient and practical of the isolation methods for the prevention and extirpation of communicable disease is however, the separation of the sick in hospitals or in their homes. But the efficiency of this method depends very largely upon the co-operation of the people themselves.

The first essential is that immediate notification of all cases of infectious disease should be given to the local sanitary authority. This authority should then be prepared to adopt immediate measures for the seclusion of patients at home or for their removal, with due precautions, to a properly appointed special hospital. Immediate notification of all cases of infectious disease may enable the sanitary authority not only to isolate the sufferers so as to prevent their becoming centres for the dissemination of the disease but also possibly to trace the original source of the disease and take effective measures for its suppression. Wealthier patients may be effectively isolated and treated in their own houses; but in the case of poorer patients it may be difficult or impossible to secure proper isolation and treatment without removal to hospitals. Poor people can not only be better isolated in hospitals than in their own homes, but they obtain greater comfort while they are sick. When they object to such removal, efforts must be made to isolate them as well as circumstances will allow.

Notification of disease is still in process of development in England. The more serious communicable diseases are compulsorily notifiable everywhere, and local authorities may extend the compulsion temporarily or permanently to any disease not on the general list if it appear advisable. The persons required to notify to the Medical Officer of Health are (1) any relative or person in attendance on the sick one or, in default, any occupier of the building, (2) every medical practitioner called upon to visit such a case.

In India there is no notification at all. Although no doubt matters are not yet sufficiently advanced for a perfect system still in large towns which have health officers and a sanitary staff much might be done. In Madras City, for instance, the Municipal Act enjoins all medical practitioners to report infectious diseases, but there is no penalty for failing to comply. Hence not even the payment of a fee for each notification secures much information. Not only should medical practitioners be made legally responsible and a penalty laid down, but each large town should maintain a register of qualified practitioners who should be bound to fulfil their duty to the community in this and other ways. Universities too should look to their fair fame and acquire power to deprive any of their graduates of their degrees if convicted of unbecoming conduct.

The provision of special hospitals for infectious diseases at all large centres of population is an important duty of sanitary authorities. Space will not admit of any details in this place about the construction and administration of such institutions. One great difficulty regarding them is to secure a well-isolated site conveniently near the population for which the hospital is intended; a second one is (especially in the first class of communicable diseases: those readily transmissible by aërial infection) to prevent dissemination of the disease by servants and attendants. The permanent buildings of infectious hospitals need not be large; but sufficient space should always be prepared for the erection of temporary sheds to provide for epidemics. The sheds attached to the Madras General Hospital are good examples for such buildings. Special vehicles must, of course, be provided for the removal of persons suffering from infectious diseases.

For the isolation in their houses of persons suffering from infectious diseases, the following points require particular attention:—

(1) All unnecessary furniture and clothes should be removed from the room.

(2) A sheet soaked in a disinfectant, such as a 1 in 20 solution of carbolic acid, should be hung over the door as a curtain. The sheet may serve some useful purpose in arresting contagium in the case of air-borne diseases, but it acts even more effectively as a danger signal to warn off intending visitors.

(3) The windows of the sick-room should be kept open as much as possible, in fact a person suffering from any communicable disease should be kept practically in the open air night and day.

(4) The attendants should, if possible, be selected from among persons who have already had the disease, or have been exposed to it without contracting it. They should avoid communication with other persons unless they have previously washed and changed clothes. All unnecessary articles, including change of clothes, should be removed from the room which the attendants habitually occupy. The clothes which they wear in the sick-room should be non-absorbent and readily washed. They should dip their hands in a disinfectant liquid (corrosive sublimate 1 in 1,000 or carbolic acid 1 in 20) on leaving the room. Their soiled clothes should be immersed in a disinfectant solution and afterwards boiled.

(5) Visitors should not be allowed to enter the room; but, if necessary, should only speak to the sick person through the curtain at the door or through a window. Other residents in the house should avoid contact with the attendants. Children, if they remain, should not be allowed to go to school or mix with other children.

(6) Excreta and remains of food should be received in a vessel containing some strong disinfectant and be afterwards buried.

Excreta, however, are not easily disinfected by fluid disinfectants; it is better therefore to mix them with sawdust and burn them at once, or put them into a large vessel containing boiling water.

(7) Soiled linen should be placed in a disinfectant solution and be afterwards boiled.

(8) When danger of infection is believed to have ceased, the patient should be well washed, bathed with a disinfectant lotion, and have a complete change of clothes before he is allowed to mix with others.

(9) The room must be thoroughly disinfected after the patient has vacated it.

(10) No remains of food or drink should be allowed to leave the sick room. Anything that is not eaten or drunk should be destroyed by fire, or boiled or mixed with disinfectants.

(11) In case of death, the body should be completely enveloped in a sheet soaked in corrosive sublimate or strong carbolic solution and be buried or cremated as soon as possible.

It is scarcely necessary to remark that it must, even if the patient and family give the most willing assistance, be extremely difficult to carry out all these precautions thoroughly in a private house, and that even in a hospital it may be possible to do so only partially. Sanitary officers should, therefore, endeavour to induce patients and their friends to consent to their removal to hospital, where they will probably be better cared for and be less dangerous to their families and neighbours than if they remained in their own homes. It must always be borne in mind, however, that even very imperfect and incomplete isolation is better than none, and may do a good deal in checking the spread of communicable diseases.

The periods of incubation and infectiousness are manifestly of much importance in considering measures for the suppression of infectious diseases. The following statement shows the period of incubation (time from reception of poison until the disease appears) and the duration of communicability of some of the most important microbic diseases so far as they are known. Practically "the power of imparting infection begins with the first symptom and lasts until the patient has absolutely recovered," that is, until "all special appearances of his disease shall have disappeared."*

Diseases.	Period of Incubation.	Period of Infectivity.
Small-pox ...	12 days	6 weeks usually.
Chicken-pox ...	10 to 12 days	3 ,, ,,
Measles	8 to 12 days or more ..	4 ,, ,,
Dengue	3 days, may be 5 or 6 ...	2 ,, ,,
Mumps	10 to 22 days	3 ,, ,,
Whooping-cough.	4 to 14 days	8 ,, ,,
Influenza ...	A few hours	1 or two weeks.
Gonorrhœa ...	4 days usually, may be 1 to 8 days.	3 weeks or longer.
Diphtheria ...	1 to 8 days	6 weeks usually.
Relapsing fever ...	A few hours to 12 days, commonly 5 days.	4 ,, ,,
Enteric fever ...	5 to 21 days, commonly 11.	6 ,, ,,
Cholera	A few hours to 5 days ...	2 ,, ,,
Malaria	1 to 3 weeks	Not transmissible from person to person except by transfusion of blood.
Plague	3 to 10 days	3 weeks or more.
Tuberculosis ...	3 weeks	Indefinite.
Syphilis	6 weeks	,,
Leprosy	2 years or more	Always.
Rabies	14 days to many months, commonly 6 weeks.	(?).

---

* S. Murphy "Infectious Diseases."

The length of the incubation period of any microbic disease depends partly on the dose of the poison entering the system at the time of infection and partly on the resistance offered by the individual. The length of the period of infectivity depends on a variety of circumstances, which differ in each case. It has recently been shown that in the case of certain diseases, *e.g.* typhoid and cholera, virulent bacilli continue to be discharged from the body for a very much longer time than it used to be thought, even after apparently perfect recovery.

Disinfection.

The object of disinfection is to destroy the contagium of disease, the pathogenic microbes finding their way out of the body of a patient and lurking in clothes, furniture, rooms and dirty places generally. We have to find means of killing not only microbes but their more highly resistant spores, at the same time doing as little damage to personal property as possible. A careful distinction must be drawn between three classes of substances; viz., deodorants, antiseptics and disinfectants.

Deodorants merely oxidise or absorb the gaseous products of decomposition and thereby destroy foul odours. Charcoal, earth, ashes, numerous patent powders, and a variety of chemicals are examples of this class. They have no very perceptible action on the microbes themselves.

Antiseptics put a stop to the further growth of bacteria and thus prevent decomposition, but they do not necessarily destroy the vitality of the organisms. Various chemicals have this power.

Disinfectants proper destroy completely both microbes and their spores. Though the rays of the sun and plenty of fresh air have a powerful influence in this direction, still they cannot be absolutely depended on and are only of use in supplementing the action of true disinfectants.

Disinfection may be performed by physical or chemical agency. In the first case heat is made use of, and is applied dry, or moist (boiling water), or by means of steam.

Dry heat.—A temperature of 140°C. continued for three hours is required to destroy all spores. Bacteria are killed by a lower temperature. Fabrics exposed to hot air at this temperature are frequently injured and it is not therefore much used except for leather or books which would be injured by moisture.

Moist heat.—(1) *Boiling* for half an hour will disinfect any article. The spores of some non-pathogenic organisms will survive boiling for even three-quarters of an hour, but this is of no consequence.

(2) *Steam.*—The great thing aimed at is to secure penetration of bulky articles. Hot air does not readily penetrate and the temperature inside a roll of blankets even after some hours' exposure to hot air may not reach a sufficient height to kill bacilli. Steam on the contrary does penetrate. Articles may be disinfected or sterilised by exposing them to the action of *current steam* (100°C.) at the pressure of the air for three hours. A current is necessary to expel the air from the interstices. Exposure for one hour to steam at 100°C. will destroy all pathogenic bacilli and their spores. The penetrating power of moist heat in the form of steam is due to the condensation of the steam as it advances into a cold object, and the formation of a partial vacuum which is at once filled by more steam from behind, and so on. As the steam condenses, it parts with its latent heat and raises the temperature of the matter in the vicinity to a high degree.

To hasten the process of disinfection steam under pressure in special machines is employed, as a higher temperature than that of boiling water can thus be obtained. 120°C. applied for 20 minutes is sufficient to sterilise any article. Steam, whether generated at atmospheric pressure, a pressure of 10 lbs., or 30 lbs. to the square inch, is saturated and will at once condense on an object cooler than itself. Saturated steam may however be further heated without increasing the pressure. It is then called superheated steam, and acts like a gas and will not condense until it has lost the extra heat which has been imparted to it. As the penetrating power of steam depends on its condensation, superheated steam is not so good as saturated steam.

A steam disinfector consists of an outer jacket containing steam under pressure and an inner chamber into which the articles to be disinfected are put. Air is first exhausted from the chamber and then steam is passed in till the required temperature (120°C.) and pressure are reached. These are maintained for 20 minutes, and then the steam is allowed to escape from the chamber and hot air is drawn in once or twice to dry the contents before they are removed. Cotton, linen and silk fabrics bear steam disinfection well, woollen goods not so well. Leather is ruined.

Chemical disinfectants—(1) *Gases.*—Chlorine, sulphur dioxide, nitrous acid, and formaldehyde all find their uses in the disinfection of rooms, particularly in the case of air-borne diseases such as scarlatina, diphtheria, influenza, measles and small-pox. A long time is expended in the process and great care has to be taken in sealing up all apertures to prevent the escape of the gas. Neither the structure of Indian houses, nor the staff at command, lend themselves to the wide adoption of disinfection by gases, so this method may for practical purposes be ignored. It is scarcely necessary to point out the futility of burning sulphur and tar in the streets, or even in the courtyards of houses, during the prevalence of cholera and other epidemics.

(2) *Liquids.*—Perchloride of mercury or corrosive sublimate in the strength of 1 part by weight in 1,000 parts by weight of water is the most generally useful. Its disadvantages are that it corrodes metals and is poisonous. For practical purposes it will be found convenient to keep a stock of a concentrated solution and to dilute this when required.

Perchloride of mercury	10 lbs.
Ammonium chloride	2½ ,,
Water	1 gallon.

Dissolve with gentle heat, stirring in an earthenware pot and add commercial hydrochloric acid, 2 gallons. This makes a concentrated solution of 1 in 3 which should be stored in glass stoppered bottles or stoneware jars.

It is customary to colour the diluted solution with a little red ink powder or aniline blue to avoid the risk of its being mistaken for pure water.

Carbolic acid is soluble in water (1 in 8 or 10). A 1 in 20, or 5 per cent., solution is necessary to destroy bacteria and spores. It dissolves more easily in hot water than in cold. Alkalies and soft soap assist in its solution. Commercial carbolic and many of the patent disinfecting fluids consist chiefly of cresols and contain only a small proportion of phenol. This however does not affect their bactericidal power, but tar oils which have no bactericidal power are sometimes freely mixed in.

Chloride of lime.—A solution containing at least ½ per cent. available chlorine should be employed. It is a powerful oxidising agent, but it corrodes metals and may exhaust itself on organic matter without injuring bacilli. Formalin, izal, chinosol, lysol, and numerous other active disinfectants find employment mostly in laboratory and hospital work; they are too expensive for use on a large scale, and possess no particular advantages over perchloride of mercury and preparations of carbolic acid and the cresols.

Potassium permanganate, being non-poisonous, is employed for water-supplies, and cooking vessels.

(3) *Solids.*—Slaked lime if quite fresh absorbs sulphuretted hydrogen and organic vapours. It corrodes metals. It cannot be classed as a disinfectant, but is a useful application for dirty walls. None of the patent powders, including carbolic powders, are anything but deodorants. Their use indeed is often to be deprecated, since people are inclined to believe that they are of real value when scattered round latrines and drains. At the best they merely mask foul odours.

Perchloride of mercury and carbolic acid coagulate albuminous matter and so do not readily reach and kill bacilli in the midst of a mass of fæcal matter or sputum. They are usually employed for sluicing the floors and walls of infected houses. Infected clothing should be allowed to soak in the solutions for at least an hour. It is occasionally necessary to disinfect cesspits and damp, slimy, muddy places. Sulphuric acid, 1 in 250, or 3 ounces to 4 gallons of fluid, is probably the best substance to use in these circumstances.

Practical disinfection

has now to be considered briefly. Our remarks on this subject may be conveniently sub-divided as they relate to disinfection (1) of inhabited rooms, (2) of vacant rooms, (3) of persons, (4) of clothing, &c., (5) of effete materials from the sick, (6) of dead bodies, (7) of sewers, cesspits, latrines, &c., (8) of food and drink. In this country all elaborate apparatus in the way of sprays and patent pumps for distributing liquid disinfectants had better be avoided. Coolies only break them and do quite efficient work with the help of nothing beyond a few buckets and tubs, wooden scoops for throwing the solutions on the walls, mops and country brushes. A great point in disinfecting a house is to burn the vast amount of foul and useless rags and rubbish that is often discovered. Removal of tiles and thatch not only admits fresh air and sunlight but assists in the rapid drying up of soaked floors.

In the disinfection of inhabited rooms, as of other places, the great importance of cleanliness and free ventilation and admission of light, as adjuvants, need scarcely be further alluded to. If the room is actually occupied by a sick person suffering from any readily communicable disease, attention must mainly be directed towards preventing the spread of infection. If the disease be of a kind easily communicable through air, special care must be taken to isolate the sufferer as previously explained. Emanations from his skin may be disinfected and be prevented from passing into the air by some local application, such as carbolized oil. The floor and walls of the room should be washed with perchloride of mercury (1 in 1,000), taking care to reach all corners and crevices and not neglecting articles of furniture. After rooms have been vacated disinfection of all parts should be most thorough.

Disinfection of clothing is very important. The infection of diseases, such as small-pox and other eruptive fevers, clings to clothing, especially woollen articles, for a long time and is thus often transported and disseminated. Sanitary authorities should see to the proper purification of infected clothing and prevent its being sent to washermen or laundries. Happily the disinfection of clothing is a simple matter. It suffices to boil it in water for half an hour. Immersion in a solution of corrosive sublimate (1 in 1,000) may be employed instead of boiling. Articles which would be damaged by wetting or boiling may be disinfected by dry heat, in places where a suitable disinfecting chamber is provided. Thick, bulky articles such as mattresses, rezais and blankets are best disinfected in a steam disinfector. If this be not possible they can be soaked in perchloride solution and spread out in the sun to dry.

Discharges from the sick, soiled rags, &c., should be received in vessels containing a sufficiency of some strong disinfectant, such as crude carbolic acid, ferric chloride, or mercuric chloride solution. In the absence of these, dried earth or sawdust may be used as an absorbent for them, this being, as soon as possible, cremated. Soiled straw of bedding, old worthless clothes, &c., should be wrapped in a sheet or bag soaked in disinfecting solution, and be taken out and burnt. The disinfection of all discharges from the bowels, and of clothes or bedding soiled with them, is particularly important in cholera, enteric fever, and dysentery, but it should on no account be neglected in small-pox and similar diseases.

The body of a person who has died of a readily communicable disease should be completely enveloped in a sheet wetted with strong disinfectant solution, and be cremated or buried with the least possible delay. If there be any discharges flowing, dried earth or chaff mixed with some disinfectant should be placed under the body.

Well made and well kept latrines should not, as a rule, be in need of disinfection. During epidemics, and when it is known that they have been used by persons suffering from readily communicable diseases, it may be useful to employ disinfectants in them.

It is certain that some, and probable that other infectious diseases may be communicated in food or drink. Recent and thorough cooking is a certain disinfectant and the best safeguard against such communication. At all times, but more especially during epidemics, it is a wise precaution to cook or boil all articles of food or drink which are not entirely above suspicion, and not to keep them after cooking in any place where they may be exposed to infection by man or by domestic animals or insects or dust.

Malaria.

Malaria is by far the most important disease to be dealt with not only in India but also in all tropical countries. The annual mortality due to malaria in India exceeds by far that of any other microbic disease, but for every death that occurs there are many more attacks, representing an incalculable amount of suffering, loss of working power, and individual and racial deterioration.

The total number of deaths in India ascribed to—

	1900.	1901.
Small-pox	91,855	89,378
Plague	92,807	283,788
Fevers	4,919,599	4,174,919

During the six years that plague has been prevailing only about 1,500,000 deaths have been recorded from it throughout the whole of India, so it is obvious that, even allowing a considerable margin for other diseases being included under the vague heading of "Fevers," malaria in one year works more havoc than either plague or small-pox does in six. Its wide-spread occurrence, and long familiarity with all its phases cause people to view its inroads with an equanimity that fails them when they are confronted with a comparatively new disease like plague, and it has come to be regarded as a necessary evil.

Recent researches have proved that if malaria cannot be exterminated over large tracts of country it can at least be rendered a rarity in large towns and kept under control in villages; also that any person who observes proper precautions can travel through, and live in, the most malarious district without taking any harm. The old theory that malaria, as its name implies, was in some way due to breathing bad air has had to be abandoned, and there is no evidence, which can be accepted without hesitation, in favour of the view that bad water is in any way concerned, though many are unwilling to entirely give up this notion. Malaria has been shown to be due to the presence of a parasite which can be demonstrated in the blood of those suffering from the disease. In its human host this parasite can live and multiply asexually for considerable periods, but if its host does not succumb the parasite itself dies in course of time. It cannot transfer itself directly to another person under ordinary conditions, but, if the blood of an infected person be injected into the veins of a healthy one, the latter also becomes infected.

Ross, working out Manson's hypothesis, first made clear how the infection is carried in nature. He found that if mosquitoes of the genus *Anopheles* bite an infected person when the parasite is in a particular stage of its development both the parasite and the blood pass into the mosquito's stomach, where the former continues its developmental cycle sexually, giving rise to a body termed the *zygote*, which attaches itself to and grows in the stomach wall of the mosquito. In ten days or more according to the temperature the zygote reaches its maximum size, bursts, and sets free a vast number of minute *sporozoites* in the body cavity. These find their way into the salivary glands of the mosquito, which are connected with its biting apparatus, and are injected, when the mosquito feeds on other people, into their blood, and so fresh attacks of malaria are started.

It cannot yet be stated as certain that there is no other means by which malaria may be spread, but it is established that the mosquito is the commonest way.

Knowing the causation of the disease and the way it is spread it is easy to see how it can be prevented. We may either attack the parasite as it circulates in the blood of the man, or prevent the mosquito biting the man, or destroy the mosquito at some period of its life, or do away with the conditions which render it possible for the mosquito to breed.

But first it is necessary to learn as much as possible about the habits and life history of the members of the group of insects named Culicidae, which includes mosquitoes, and this can only be done by actual observation out of doors and by breeding them up in confinement. Attention will only be drawn to the three genera *Culex*, *Anopheles* and *Stegomyia.*

Female mosquitoes only suck blood. Males may be distinguished from females by their thick feathery antennae. All mosquitoes lay eggs on water, which hatch, and larvæ emerge. The larvæ feed greedily on vegetable matter and minute living forms in the water, cast their skins several times, and finally turn into pupæ or nymphæ. A pupa does not eat, and in the course of a day or two bursts open and the fully developed mosquito or imago comes out and flies away. Mosquitoes cannot breed in trees * or on damp ground or anywhere except in water.

Distinguishing characters of

—	Anopheles.	Culex.	Stegomi
Egg or ovum.	Laid separately usually. Found in tanks, wells, irrigation channels, paddy fields, rain water puddles, pools in river beds, &c.	Laid in boat-shaped masses. Found in same places as anopheles, but also in pots, tins and collections of dirty water in and near houses.	[illegible]
Larva ...	Has no respiratory tube. Floats horizontally.	Has a conspicuous respiratory tube. Appears to hang at various angles from surface of water.	[illegible]
Pupa ...	Not easily distinguished.		[illegible]
Imago ...	Is generally straight.	Is hump-backed.	[illegible]
M. and F....	Rests at varying angles with a vertical wall. Wings spotted, barred or deeply colored.	Rests parallel with a vertical wall. Wings clear, unspotted, except in one or two rare species.	[illegible]
Male ...	Palpi bulbous at ends, same length as proboscis.	Palpi feathered at ends and pointed, longer than proboscis.	[illegible]
Female ...	Palpi same length as proboscis.	Palpi very short.	

---

* They can, however, breed in the rain water which collects in the stumps of broken or cut bamboos, in hollows in trees, and in the axils of large leaves, and thus may abound in an apparently waterless jungle.

Stegomyia resembles culex in the above characters. It is distinguished by the microscopical appearance of its scales. It is the common black and white "tiger mosquito," plentiful both in habitations and jungles, and it feeds voraciously by day.

A little practice enables Anopheles and Culex to be distinguished from each other and from all other kinds of two-winged flies without fail. A microscope is necessary to differentiate the numerous species of Anopheles and Culex, but observation and a hand lens will go a long way.

As far as is yet known only Anopheles can carry malaria; and the researches of the Indian Malaria Commission tend to show that though all the species of Anopheles can be experimentally infected, yet in nature it is probable that the commonest species such as Anopheles Rossii do not function as carriers. In the most malarious places it is seldom that more than 6 per cent. to 8 per cent. of infected insects are found amongst the species that do carry. The prevalence of malaria in any area is judged by the percentage of young children under 5 who are found to have the parasite in their blood, and the percentage of the population, taken in 10-year age periods, who have enlarged spleens. As the years go by those who do not succumb to the malarial infection appear to acquire a relative immunity, but this applies only to places where the chances of repeated infection during childhood are very numerous.

In places where malaria is not very prevalent, and the chances of infection are not numerous, age confers no sort of immunity. It is possible that amongst other things malaria is responsible for a good deal of the chronic kidney disease which is so common in India.

Anopheles do not seem to fly further than from $\frac{1}{4}$—$\frac{1}{2}$ mile from their breeding places as a rule: a belt of trees between a village and a breeding ground probably arrests the progress of the majority of mosquitoes.

Preventive Measures.—Destroying the parasite in the blood by the administration of quinine is obviously an impracticable measure to apply to an undisciplined population. It is of value in connection with bodies of men under control.

Quinine is invaluable as a prophylactic against malaria; not for daily use over long periods, but taken in doses of 15 grains each twice a week when exposed to infection in travelling in malarious districts. As a curative agent it is generally given in too small quantities and for too short a time. Adults can take 20—30 grains daily until the fever has ceased, then 10 grains every second day for a week longer. Relapses are not infrequent even after a course such as this. Doses of less than 10 grains are useless for adults.

Protection of the body from bites is largely a matter of personal care. The intelligent use of mosquito nets at night and the avoidance of bites after sunset and before sunrise will save a man from many an attack. Mosquito proof houses are not likely to be often seen in a hot and poverty-stricken country like India, but those who can afford it would derive considerable safety and much comfort from a wire gauze protected room in a verandah for sitting in after dark.

The destruction of adult mosquitoes is neither an easy nor satisfactory way of dealing with the matter. Far simpler and more effectual a plan is to hunt out the breeding places and see if they can be filled up or drained. Much can be done in a town in this direction by filling up or draining puddles, ditches, low ground, old wells, dirty pools and tanks. Mosquitoes of all kinds are a pest, even if not actually dangerous, and measures undertaken in a town or village to exterminate Anopheles should be understood to include Culex and Stegomyia also.

Mosquitoes in houses are no more a necessary part of life in the tropics than flies are, both are dangerous, both indicate defective sanitation, though in different directions, and the presence of both points frequently to culpable carelessness either on the part of the house-owner himself or of his immediate neighbours.

Wet cultivation within town limits and in the immediate vicinity of villages should cease.

Larvæ can be readily destroyed by the application of kerosine oil to the surface of a well or puddle. The oil forms a film on the surface and obstructs the respiration of the larvæ which consequently die. Practically it is often difficult to get the oil to spread satisfactorily. Much agitation of the water and painting the surface with a mop aids the formation of a film. This is of course only a temporary measure and has to be repeated at suitable intervals of a few weeks whenever fresh broods of larvæ have hatched out.

Extensive drainage of the sub-soil may by lowering the water level keep certain places dry which formerly served as breeding grounds; conversely, works which obstruct the flow of the sub-soil water and too free irrigation may increase the amount of malaria.

In the absence of suitable breeding places Anopheles cannot exist and hence there is no malaria. There may be both men, breeding places and Anopheles, and yet no malaria, because there are no parasites. If parasites are then introduced by the arrival of an infected person malaria will take root and spread if the climate be favourable. If the climate be not favourable the infection will not spread. In the light of this knowledge common sense will enable a reasonable explanation to be found for most of the problems which arise in connection with malarial infection, and will suggest what combination of preventive measures is likely to be most effective and at the same time most acceptable to the populace which is being dealt with.

Cholera.

Cholera is a disease which has its home in India, being endemic in Lower Bengal: many other districts including the Madras Presidency are never entirely free from it. It is generally admitted to be due to the presence of Koch's comma-bacillus in the intestine. This microbe or vibrio generally obtains entrance into the body with excreta-contaminated water or food. It is capable of rapid multiplication outside the body in water and damp earth, but certain common saprophytes are antagonistic to its growth. It does not form spores and is readily destroyed by drying. A high temperature is necessary for its growth. It is kept alive in the moist soiled clothes of cholera patients, and was found by Koch in the water of a Calcutta tank, where such clothes had been washed, and which was being drunk by people among whom the disease was epidemic. Sand obtained from a river-bed which had been fouled with cholera excreta was used in a filter at Lucknow and caused an outbreak in a British Regiment. The vibrio varies greatly in virulency from time to time. It has several times been isolated from the evacuations of healthy persons, and also some while after recovery from an attack.

During an epidemic diarrhœa is generally found to be also unusually prevalent and it is probable that numbers of these cases are really mild attacks of cholera.

The mortality varies from 30 per cent.—50 per cent.; in limited outbreaks it may be much higher. It is quite possible that the very mild cases are as dangerous to the community as the fatal ones and that water contaminated with their excreta will convey the infection equally well. The vibrios are also present in the vomit of cholera patients.

Predisposing causes are fatigue and depression combined with want of food. It is probable that the vibrios will not cause an attack if they pass into a perfectly healthy stomach and intestine. Fear may predispose, but cannot cause an attack in the absence of the causative microbe, nor need any hesitation be felt in entering a cholera house: the disease cannot spread through the air.

The disease prevails chiefly in crowded parts and as a rule in the most* insanitary areas. It attacks most readily beggars and chronically underfed and, therefore, unhealthy people. In times of famine especially it runs riot.

Its *seasonal prevalence* varies with the local conditions. Before the rains, when water is scarce, contaminable sources may be drawn upon which are usually untouched, and an epidemic may result. In Madras City cholera almost invariably begins at the end of July or in August when light showers have fallen which may have washed foul matter into wells. Heavy rain on the other hand sometimes stops an epidemic, though it may increase again afterwards. In Madras Presidency it appears to reach its maximum rate of mortality between June and September in those districts which receive the South-West monsoon, and during October, November and December in those which get the North-East monsoon. Nothing really definite is known about the seasonal influences which determine the spread and cessation of epidemics of cholera.

Mode of infection.—The conveyance of cholera by men from place to place is a certain fact. It does not travel faster than men can travel and invariably spreads along railway lines, rivers, canals and from port to port: always on the great lines of communication. It constantly breaks out among the crowds who congregate at fairs and pilgrimages and is frequently carried through the country by infected parties of them as they travel to their homes.*

---

* So long as the insanitary conditions remain, epidemics invariably haunt the same localities, and the first appearance of the Cholera in Bermondsey in 1848 was close to the same ditch in which the earliest fatal cases occurred in 1832. The first case of cholera that occurred in the town of Leith took place in the same house and within a few feet of the very spot from whence the previous epidemic of 1832 commenced its course. On its reappearance in 1848 in the town of Pollockshaws, it snatched its first victim from the same room and the very bed in which it broke out in 1832. Sir D. Galton, *Society of Arts*, 1886.

As to the communicability of cholera by water soiled with cholera excreta, the first well-investigated cases were recorded by Dr. Snow in 1849 and in 1854 in England, and since then very numerous instances have placed the matter practically beyond doubt. In 1886 cholera was largely prevalent in Calcutta, and it was found that most of the cases took place in those localities where the public water supply was most deficient and that a large grouping took place round tanks.† Its conveyance by food is probably less frequent. A case is related ‡ where an epidemic occurred among persons who partook of rice which had been spread on a mat in a hut where a man had died from cholera Cases of conveyance by infected articles have not often been traced with certainty. In 1864 cholera existed in the camp of the 74th Highlanders at Guindy near Madras. Two cartmen who were engaged in transporting the tents of the regiment appropriated some straw which had been spread in the tents of cholera patients. On their way home to Chingleput (more than 20 miles distant), they were attacked with cholera and died the day after their arrival. The disease then spread in the town which had been free from cholera for years.§ If infected articles may convey the disease, it must be possible for healthy persons to convey it on their clothes or bodies. Flies probably take an important part on occasions in the dissemination of cholera. Not only can they carry the microbes on their feet from latrines and cholera houses, but their excreta also contain the vibrios in a virulent state after they have been feeding on cholera dejecta.

---

* Its propagation by persons returning from Hurdwar fair is the most often cited instance, and Dr. J. M. Cunningham himself stated "that the cholera went with the pilgrims in every direction is a fact which admits of no dispute." Pilgrims from the Tirupati and Periapalaiyam festivals are well known to be frequent carriers of cholera to Madras and other places. A severe outbreak in the town of Cuddapah during the famine of 1877 was witnessed by the author, and could be traced to no other origin than the use of an important well by a gang of labourers among whom the disease had broken out and who were encamped outside the town. In 1887 "in Midnapore cholera was imported by the pilgrims returning from Puri."

† See reports of Health Officer Dr. Simpson. The greater mortality in the suburbs than in the city of Calcutta may be explained by the polluted tanks which afford much of the water-supply of the former. In 1886 the total mortality from all causes in Calcutta City was 26·42 and in the suburbs 40·51.

‡ *Hygiene of Cholera*, by Surgeon-General C. A. Gordon. The original report is not referred to.

§ Madras Sanitary Commission, 1866.

Prevention.—General sanitary measures conducive to purity of earth, air, dwellings, food and water are most effective. Purity of water is particularly important, and a town which has a water-supply above suspicion is scarcely likely to suffer severely from cholera. If cholera actually breaks out in a town all sources of water should be looked to and suspicious ones abandoned, wells should be treated with potassium permanganate and all water used in the house should be boiled. Great attention must be paid to the careful removal of rubbish and filth, and as a personal precaution every care should be taken to avoid any gastric irritation, or disturbance of digestion, by eating unripe or overripe fruit or anything that is known to disagree. A surfeit of melons or jack fruit cannot give cholera but it may pave the way for an attack.

Isolation of the sick is important, and a hospital is preferable to a private house both for the sake of the patient and because gatherings of sympathetic relatives, which are often followed by injudicious feasting, do not then take place in the infected house, and one frequent method of dissemination is thereby avoided. The excreta must be carefully disinfected and should on no account be put in the common cart or even a sewer without having first been rendered harmless by being received into a vessel containing disinfectant and afterwards boiled, or by being mixed with sawdust and burnt. All soiled clothes and rags should at once be placed in disinfectant or in boiling water, and liquid disinfectants should be freely used on the floor and walls near the patient. Attendants must be careful not to infect themselves by eating food with excreta soiled hands. With care they should run no danger.

No food and drink should remain in the sick room, and none which has been in the room should be tasted by others: it should be destroyed. Milk is particularly liable to contamination. All cold food should be avoided by other members of the household.

At fairs, festivals and other large temporary gatherings the local authority should make due provision in advance for an uncontaminable supply of water, for sufficient latrine accommodation, and for separation of the sick in case of cholera occurring. Such precautions are necessary not only at the centre of attraction but at the halting places on the routes leading to and from it.

Small-pox.

Small-pox is a no less preventible disease than cholera, and it is more loathsome and the cause of more suffering, although neither its absolute nor its relative mortality is so great. The former for 1881–85 in Madras municipal towns was 2·2 per 1,000 of population, and more than 20 per cent. of persons attacked die. It is essentially an epidemic disease, though it must be regarded as endemic nearly everywhere in India, and severe epidemics of it recur generally at intervals of about five years. The last epidemic culminated in 1884, and in that year there were 333,000 deaths from small-pox in India (61,247 representing a death-rate of 2·1 per 1,000 of population in Madras). In London, in 1771–80, small-pox caused 10 per cent. of the total deaths, in 1831–35, 2·7 per cent., and in 1861–70, only 1·1 per cent. (0·2 per 1,000 of population). It may thus be seen that before the introduction of vaccination, small-pox was more fatal in London than it is now in India, while at the present day it is very much less so.

The contagion of small-pox is very persistent, and it may act through a considerable distance.*

It is commonly propagated through the air in the vicinity of the sick and by infected articles, such as clothes which may, for instance, give the disease to a washerman's family and thence convey it to his customers, or such as carriages in which a diseased person has ridden, or such as the clothes and bodies of persons who have been in contact with the sick, as well as by direct contact. The importance of isolation and disinfection in this disease is therefore great.

One attack of small-pox protects against a second attack generally for life, though the protection becomes weaker as the time increases after the attack.†

Nature of Small-pox.—Small-pox is a typical acute microbic disease. It is peculiar to man, though several other animals suffer from closely similar diseases.

---

* Probably for at least a mile through the air. *Vide* Mr. Power's observations in Dr. Buchanan's Report to L. G. Board, 1885. The risk naturally diminishes rapidly as the distance increases. "Houses within a radius of half a mile have been attacked at three times the rate of those between half a mile and a mile of it (small-pox hospital), and at nearly four times the rate of the parts beyond."

† Dr. Crombie (Dacca, 1885) noticed the occurrence of small-pox in prisoners who bore marks of inoculation, and he found that 38 per cent. of such prisoners were susceptible of vaccination.

The microbe has not yet been isolated and it is not clear whether it is a coccus, bacillus or a protozoal parasite. For the sake of convenience cases of small-pox are divided into (1) discrete, in which the pustules are separate from one another, (2) confluent, in which the pustules are so closely packed that they touch one another, (3) malignant, a rapidly fatal form, (4) modified, in which the course of the disease and the appearance of the eruption is modified by previous vaccination.

Prevention of Small-pox.—Under this head we shall consider (1) isolation and disinfection, (2) inoculation and (3) vaccination.

Isolation and Disinfection are undoubtedly efficacious, but it is difficult to carry them out thoroughly. Small-pox hospitals should be as far as possible from dwellings, and every precaution must be taken to prevent the spread of infection by attendants and servants, as well as by other means. In London such hospitals were found to be in some way centres of infection.

Inoculation, first practised in eastern countries, was introduced into England from Turkey in the first half of last century. It is even now unfortunately practised by a few ignorant persons in India and is quite popular in Burma. It did not cause any diminution of the general mortality from small-pox. The inoculated disease was milder and much less fatal than that otherwise acquired, and it produced immunity from a second attack; but it propagated and diffused the contagium of the disease and rendered it more difficult to stamp out, while it added greatly to the danger of the many who did not submit to the operation. Inoculation of small-pox is then strongly to be condemned, mainly because it propagates and supports the disease which we want to suppress.

Vaccination.—Dr. E. Jenner, in the year 1798, first published an account of the great discovery. For many years previously he had been making observations, but he had great difficulty in obtaining acceptance for his views. When put to the test of experiment, however, they speedily triumphed; and in a few years vaccination became very general among all civilized nations.

There was a popular belief in some parts of England that persons who had suffered from "cow-pox"—sores which sometimes appeared on the hands of milkers who milked cows suffering from a certain eruption on their teats—could not get small-pox. Jenner investigated this belief and concluded that it was founded on fact. At length he inoculated a boy with the cow-disease and found that he was then proof against small-pox inoculation. He also discovered that the cow-pox could be transmitted from person to person by inoculation. The advantages of vaccination over small-pox inoculation are that it affords similar protection not only with comparative safety, but practically with absolute safety, that it does not propagate a dangerous nor very easily communicable disease, and that it ought to enable us eventually to extinguish small-pox altogether, though it is doubtful if this consummation would be quite popular with the devotees of Mariamma.

"The protection which vaccination affords against small-pox is manifested in two ways; firstly, by the immunity from that disease which, as a rule, it confers; secondly, by the modification which, when immunity is not complete, it induces in the course and severity of the disease."[*]

The degree of protection afforded by vaccination depends mainly upon (1) the time which has elapsed since its performance and (2) the mode of its performance—the protection given by vaccination in three or four places being much more perfect than that conferred by vaccination in only one spot. The comparative and absolute immunity from the disease, and the greatly lessened mortality when attacked, as well as the value of vaccination at several points, are shown by abundant statistics.

The following are Dr. Marson's well-known statistics (5,000 cases):—

(1) Unvaccinated mortality per cent.	35·00
(2) Stated to have been vaccinated, but having no cicatrix	23·57
(3) Vaccinated—	
(*a*) Having one vaccine cicatrix	7·73
(*b*) ,, two ,, cicatrices	4·70
(*c*) ,, three ,, ,,	1·95
(*d*) ,, four or more vaccine cicatrices	0·55

The operation of vaccination consists in the insertion of vaccine lymph into punctures made in the skin, or rubbing the lymph into abrasions made by scraping the skin with a lancet point or with an instrument made of three or four needles together. At the end of the second day a small reddish elevation (papule) is perceptible. By the end of the fifth day this has become a whitish blister (vesicle) with a central depression. On the eighth day it is pearly and distended with clear viscid fluid (lymph), the central depression being well marked and the vesicle surrounded by a circle of inflammation. This continues to enlarge and swell for two days longer, when it begins to subside and the vesicle to dry. About the fourteenth day only a dry brown scab remains, which falls off about a week later. The scar (cicatrix) which is left is depressed and marked with little pits (foveated).

---

[*] Dr. E. C. Seaton.

Vaccination instruments are best purified by being inserted for a second or two into the flame of a spirit or other lamp before each vaccination.

Re-vaccination is important because the protective effect of primary vaccination, especially if it has been imperfect and only performed at one or two spots, gradually becomes less. Young people should be re-vaccinated on reaching the age of puberty; and, whenever a case of small-pox occurs in a house, all residents in it should be immediately vaccinated. If a person be vaccinated within two days after exposure to small-pox contagion, small-pox is entirely prevented, and if on the third day it is "modified" and rendered less severe.* Later than the third day vaccination has no protective power and develops concurrently with the small-pox. It is in such cases that mothers are inclined to state that the vaccinator has given her child small-pox.

Vaccination, even in the youngest infants, is practically without danger if properly performed. The lymph should be taken at the proper time from a healthy subject and the person to be vaccinated ought not to be sick at the time. Erysipelas may attack the vaccinated spot, as it may attack a boil or a scratch if the subject be exposed to infection. Syphilis has been communicated by careless operators, but it has been shown that lymph obtained from an infant with congenital syphilis does not communicate the disease if the infant's skin be free from eruption at the time.† For this reason "arm to arm" vaccination is being everywhere abandoned and "calf to arm" vaccination has been introduced to guard against the communication of human disease by careless vaccinators.

---

* Vaccination is protective when the areola is developed (ninth day) and the incubation time of small-pox is twelve days. *Vide* Marson (Reynold's Med.).

† In L. G. B. (England) Report for 1886 in 800,000 cases of vaccination cited, not one case of syphilitic transmission was known.

The original cow disease is more severe than humanized vaccinia; no attempt is, therefore, made to reproduce it, but the shaven belly of a calf is inoculated with humanized lymph. The cycle of the disease is shortened, the vesicles maturing in four or five days and producing little or no secondary inflammation or constitutional disturbance in the animal. A calf is able to support a hundred vesicles without inconvenience.

Vaccination, in the countries where it is general, has had a remarkable effect upon the statistics of small-pox. We have seen that it has caused an enormous reduction of small-pox mortality; but it has also shifted the mortality of that disease from infancy to mature age. In England, 50 years ago, the deaths from small-pox under five years of age were three times as numerous as those above that age; these proportions have gradually changed as vaccination became more general, until at the present day they are reversed, the deaths above five years being three times as numerous as those under. Most of the deaths now * are above the age of 20. The evident explanation of this fact is that the influence of primary vaccination gradually diminishes; and the deaths from small-pox are now mainly confined to non-vaccinated persons and to persons who have been (often imperfectly) vaccinated in their infancy and have never been re-vaccinated. These statistics afford a strong argument in favour of re-vaccination.

We may also conclude from them that where the infantile mortality from small-pox is greater than the adult mortality from that disease, there is almost certainly defective vaccination. In 1884, in Bengal 72 per cent. and in Madras 64 per cent. of the deaths were of children under 12 years of age. In Madras City, during the epidemic of 1883–85, no less than 97 per cent. of the total deaths were in infants and children. This proves that infantile vaccination was much neglected, and that the adult population was largely protected by previous attacks of small-pox or by vaccination. After this epidemic, when vaccination was rendered compulsory in 1885, small-pox almost disappeared from Madras: but this disappearance was no doubt partly due to the protective

---

* This was in 1889. Since 1890, however, a reversion has been taking place and the infantile mortality rising, the reasons undoubtedly being neglect of vaccination and the permission of "Conscientious objections."

effect of the preceding epidemic (and possibly to some concealment of cases).* Vaccination is now compulsory in all municipal towns in Madras and it is gradually being rendered compulsory in village unions too. Although in a town with a properly constituted health department and a population alive to their duties to the community it might be possible to control small-pox by immediate notification, isolation and disinfection, it is hopeless to look for help to any measure in India but compulsory vaccination. Since small-pox can be absolutely prevented by efficient vaccination and re-vaccination it is entirely the fault of any person if he gets an attack. As a man with small-pox may do infinitely more harm to the community than a common thief, it has recently been suggested in Europe that an attack of small-pox should be looked upon as a criminal offence and punished accordingly.

Dysentery and Diarrhœa.

In all tropical countries the mortality from bowel diseases is very high and from diseases of the lungs comparatively low, the opposite of what occurs in cold climates. Under the term 'dysentery' is still included a variety of diseased conditions due to causes which are not thoroughly known. Amongst these is one due to the invasion of the intestine by a bacillus and another to the presence of an amœba. Dysentery at times is epidemic and is then readily communicable by food or water contaminated by fæcal matter. It is particularly fatal in times of famine when people eat much indigestible material and drink any water obtainable. General improvement of sanitation in a town leads to a diminution in the mortality from bowel diseases, and persons who are careful about the purity of their food and drink run little risk of an attack, though accidents may happen to all.

Dysentery prevails at the same times and in the same places as malaria, but the two diseases are quite distinct.

Infantile Diarrhœa.

In all countries a large proportion of the deaths amongst young children is caused by diarrhœa. Excluding those in which the principal factor is improper feeding, it appears certain that many cases are due to definite microbic infection. Diarrhœa frequently becomes epidemic during the autumn months—August, September and October—and prevails in England chiefly amongst bottle-fed infants, whose food is obviously exposed to contamination which breast-fed infants are likely to escape. It has been noticed that dry, dusty summers are followed by a much more extensive outbreak of diarrhœa than wet summers, and it also appears that those towns which are most attentive to the cleanliness of their streets and wash the surfaces of their roadways most freely, suffer least from infantile diarrhœa. If, as is probable, the microbes which give rise to this diarrhœa flourish chiefly in the dirt and organic matter which collects in the streets, it is clear that they can be spread about most readily in dry, windy weather, and that rain which washes the roadways will carry them away. Similarly, in India it happens that, if August and September are wet months, the mortality from diarrhœa is greatly lessened. Though in India all infants are breast-fed they often get other food as well, and the mortality from diarrhœa is in some years exceedingly high.

---

* In a well-vaccinated community, the vaccination-rate ought not to be much lower than the birth-rate. The Madras Presidency birth-rate is about 42 per 1,000 and vaccination-rate 23. By 1900 the vaccination-rate had risen to 30 per 1,000.

Prevention.—Well-paved or well-metalled roads, free watering of the surface in dry weather and careful removal of all rubbish and excreta will go a long way towards keeping a locality free from epidemic infantile diarrhœa.

Enteric or Typhoid fever

is a specific disease due to infection with the typhoid bacillus. It generally enters the body in water contaminated with human excreta, but may, like cholera and perhaps dysentery, be carried about by flies. Dried fæcal matter containing the bacillus may also be blown about by the wind and thus spread the disease. It is of world-wide occurrence, and in India affects both Europeans and Natives. The contagium leaves the body both in the fæces and in the urine, and it has been shown to be present in the urine sometimes for many weeks after convalescence. The disease is not air-borne in the sense that small-pox is, so mere proximity with a patient is not dangerous. Similar precautions must be taken in disinfecting the excreta as in cholera. General preventive measures consist in securing pure water and good drainage, and cleanliness of surroundings.

Plague.

In 1896 plague once again appeared in India in an epidemic form and has so far resisted all efforts to exterminate it. The causative bacillus enters the body either by inoculation through a skin wound, or by inhalation, or by the mouth. It leaves the body in the sputa in pneumonic cases, and to a less extent in the excreta. With the exception of the pneumonic cases, plague is not very readily communicated from man to man; infection seems generally to be derived from some common source outside the body. The contagium can be carried about in infected clothes or goods. The disease does not very quickly establish itself in a fresh centre, but when it does so, it is extremely difficult to eradicate it. It is essentially a disease of locality. Rats and many other animals die from it, and may be the means of carrying it to uninfected places either by land or by sea on board ships. It is possible that fleas may at times transfer the infection. Filth and overcrowding are prominent factors in determining its spread, and persons who live well and under sanitary conditions seem to run but little risk. The mortality varies from 60 per cent. to 90 per cent., but depends very largely on the hygienic surroundings.

Prevention.—The main thing is to prevent the disease from establishing itself, and, if prompt information can be obtained about all imported cases and immediate isolation of the patient secured, thorough disinfection of the premises he occupied and observation of all persons he came into contact with, so that any one who shows symptoms of illness can be at once dealt with, will almost certainly be successful in preventing an outbreak. A careful system of observation of all arrivals from infected areas, and restrictions on the importation of rags and such like, are invaluable measures. If plague has established itself or become indigenous, little can be done beyond isolation of the sick, observation of contacts and careful disinfection of infected houses. If a village or one part of a town only be infected, a great measure of success attends complete evacuation; all the people moving out into camp while their houses are cleaned, disinfected, and opened up to the sun and air. Inspection of travellers by rail and sea has been the means of arresting a large number of cases.

Inoculation with Haffkine's prophylactic confers a high degree of personal immunity which lasts for six months or so, and should be tried on a large scale whenever plague has become indigenous.

Destruction of rats should be undertaken whenever plague threatens, but too much stress cannot be laid on perfect cleanliness of houses, streets, and person, and the admission of plenty of fresh air and light.

Relapsing fever

appears only when the surroundings are insanitary, and overcrowding exists together with destitution and semi-starvation. The exciting cause is an active spirillum which is found in the blood during the paroxysms. The mortality in Bombay of recent years has been about 15 per cent. The disease is propagated by direct contact.

Measles and Chicken-pox

are common enough diseases in India. The only interest of the latter lies in the difficulty occasionally experienced in distinguishing it from mild and modified small-pox. If there be any doubt the more serious disease should be assumed. The mortality from chicken-pox is *nil*. Measles on the other hand is responsible for a good many deaths amongst children. It is readily communicable through the air and by contact. Sufferers should be isolated at home, as it is not often practicable to admit them into a hospital, and steps should be taken to prevent them from attending school until the period of infectivity has passed.

Tuberculosis

exists all over the world and accounts for the deaths of nearly one-seventh of mankind. Tubercular disease of the lungs, or phthisis, is a common disease in Madras and in many other parts of India. It is also common amongst cattle in Europe, but not so much in India: in the Madras Presidency for instance it is exceedingly rare to find a tuberculous animal in a slaughter-house. The exciting cause is the tubercle bacillus which finds entrance by inhalation. It leaves the body in immense numbers in the sputum of the infected person, and, being able to survive desiccation, it may be found in the dust of the rooms he inhabits and spits about in.

Phthisis is encouraged by dampness of soil, overcrowding, defective ventilation, sedentary occupations, and bodily debility from any cause; a predisposition towards it is inherited.

Prevention resolves itself into living in dry, light, well ventilated and clean houses, attendance to personal hygiene, and avoidance of contact with phthisical persons.

Stringent regulations are now in force in certain countries with the object of putting a stop to spitting in public places. Every person suffering from phthisis should be made aware that he is spreading the contagium by indiscriminate expectoration. Phthisical sputa should be received into a vessel containing disinfectant and afterwards burnt.

Syphilis

resembles tuberculosis in its slow progress and its lengthened duration. It is assumed to be of microbic nature from its clinical history and natural characters, though its specific microbe is not yet known.* So far as is known, it is communicable only by inoculation. Inoculation may take place accidentally in various ways; for instance, surgeons are not rarely inoculated through scratches on their fingers; babies have infected nurses, and razors have also communicated the disease †; but it is habitually communicated by sexual intercourse. It is mainly spread by uncleanly prostitutes.

Though syphilis is not often directly fatal, it often causes much suffering and prolonged ill-health and degenerations of organs which may conduce to death from other causes. It is also transmitted frequently to the offspring of syphilitic parents (congenital syphilis). The disease is common all over India, very prevalent in some places; but accurate statistics of it are wanting. In 1885, 4,000 cases of syphilis (in 14,000 of "venereal diseases") were treated in Calcutta hospitals.

Prevention of syphilis.—This disease, as well as gonorrhœa and local contagious sores, could be greatly mitigated, if not completely stamped out, by organized inspection and the isolation and treatment of diseased prostitutes. Those of the lowest class require most attention, since they are the most active agents in its propagation. Such inspection and treatment was carried out for many years at large Military stations in England and in India with great benefit to the troops, to the civil population, and to the prostitutes themselves; but in 1883 some misguided, but very clamorous, persons in England raised an outcry against the *Contagious*

---

* Mr. Jonathan Hutchinson, one of the highest authorities on the subject of syphilis, says "I have always . . . . held firmly to the belief that it is due to . . . . a living microbe." Medical Soc. of London, 20th February 1888.

† *Lancet*, 20th November 1886.

Diseases Act which has resulted in its—let it be hoped only temporary—abrogation. Syphilis has been increasing in the army since that time.* Prostitution cannot be suppressed by the State so long as sexual passion and present social conditions remain. It is regulated by law in many European States with obvious benefit. So far from promiscuous immorality being encouraged thereby, the reverse is the case; for many young girls who wish to change their mode of life are enabled to do so, and it is probable that domestic morality is increased.

Leprosy

is due to a bacillus which slowly multiplies in the tissues. Owing to the long incubation period and very chronic nature of the malady, it is very difficult to come to definite conclusions as to its communicability. Most authorities, however, are agreed that it is communicable and particular stress is laid by Sticker on the infectivity of the nasal discharges. The disease is found in most parts of India and does not seem to be much if at all on the increase.

Salt-fish is credited by Hutchinson with an important part in its causation. Marriages of lepers should be discouraged. The only practicable preventive measure is the segregation of all lepers in hospitals or asylums, or in leper colonies or villages.

Voluntary leper asylums have been opened in many towns in India, but compulsion is not resorted to. Lepers should not be permitted to follow any occupation connected with the sale of food or drink, or which brings them into intimate contact with other people.

Other communicable diseases which are either unknown or else rarely seen in India are not touched upon, nor are those diseases mentioned in which preventive measures cannot as yet be undertaken by reason of our want of knowledge as to their causation.

---

* For evidence, see Parkes' *Hygiene*, 7th Edition, pp. 473-78. Lord C. Beresford stated in the House of Commons (September 1886) that "the large increase in the sick list in the navy was due to the abrogation of the Contagious Diseases Act and to the campaign recently undertaken."

CHAPTER XI.

VITAL STATISTICS.

PRELIMINARY CONSIDERATIONS.

"STATISTICS are the numerical expression of collected facts and their relations." * Vital Statistics may be defined as the statistical method † applied to the investigation of facts relating to human life.

Statistics are necessary for ascertaining and expressing with precision aggregate facts which are so large numerically as to be otherwise evident in only a vague and general manner or to completely elude ordinary observation, for determining the relations of such facts to each other, and for making inductions as to the causes and laws of such facts.

The units composing the aggregate numbers ("primary statistical quantities") which form the bases of all statistics, must necessarily be properly collected and grouped together. One of the commonest sources of untrustworthiness in statistics is the incorrect enumeration of grouping of units. It is desirable that all statistics should be accompanied with descriptive statements explaining the method by which the units have been collected and grouped together, so that any possible or probable inaccuracies may be taken into account.

Primary numbers, or simple statistical quantities, must contain all the units of a like kind, which are to be enumerated. The errors which are likely to exist in such numbers

---

* H. King: *Madras Manual of Hygiene.* This is the clearest and best definition I know. A yet briefer, but more limited, one which may be suggested for Vital Statistics is *sociology investigated mathematically.* This is but an abbreviated paraphrase of M. Block's well known definition: "la science de l'homme vivant en société en tant qu'elle peut être exprimée par les chiffres." *Traité de Statistique,* 1878.

† The "*statistical method*" is a scientific procedure (1) whereby certain phenomena of aggregation not perceptible to the senses are rendered perceptible to the intellect and (2) furnishing rules for the correct performance of the quantitative observation of those phenomena." Art. "Statistics" in *Encyclop. Brit.*

are due to (1) omission of correct units, or (2) inclusion of incorrect units. For instance in a return of deaths from cholera in a population (1) some cholera deaths may be omitted owing to improper statement of cause or concealment of death, or (2) some deaths from dysentery and diarrhœa or other diseases may be included; the result being in either case an incorrect *primary number* expressing the deaths from cholera. Clear definition of the distinctive characters of the group to be represented, and accurate collection of all units belonging to that group, and of no others, are necessary in order to obtain a correct primary number.

Statistical facts may be expressed either (1) by simple statement of one or more primary numbers, (2) by the *ratio* of two or more numbers, or (3) by *averages* (*means*) deduced from two or more numbers.

Ratios,

or proportions, are useful in showing the relative numerical importance or size of two primary numbers which are to be compared together, and in reducing them to a uniform scale, so that they may be compared with other proportional numbers. For example, if the mortality in three towns was as follows:—

Towns.	Population.	Deaths.
(1)	4,680	117
(2)	33,700	1,078
(3)	18,375	496

the actual numbers do not convey a clear idea of the relation of deaths to population in any one of the towns or of the relative mortality of the three towns. But if we state that out of every 1,000 persons in each town the following number died:—

(1)	25
(2)	32
(3)	27

the ratios are at once evident.

The most usual, and generally the best, method for comparing two numbers is to state one (usually the larger) as 100, and the other as a *percentage* of this.

Another method of stating a ratio, which is sometimes useful (for it appears to convey a more definite and vivid impression to minds which are unused to deal with figures is to reduce the smaller number to unity and state it as "one in so many." For instance, the mortality of the three towns in the above example may be stated as 1 in 40, 1 in 31, and 1 in 37, respectively. This method possesses the disadvantage that the changing number becomes greater or less *inversely* as the facts it represents increase or diminish in number. A percentage increases or diminishes *directly*.

When several proportional figures have to be compared together, the percentage method is especially preferable. If the two numbers differ greatly in magnitude, it is convenient, in order to avoid fractions, to state the larger one as 1,000 or some multiple of 1,000;[*] the smaller one being proportionately increased.

Fallacies of Ratios.—The value of a ratio as an average statement of fact, or as an indication of future probability, depends mainly upon the number of units upon which it is based: the larger the number, the more trustworthy is the ratio. For instance, if in a household of ten persons two deaths happened in one year, the mortality of that particular household was at the rate of 200 per 1,000, or 1 in 5 per annum; but it would be manifestly absurd to accept this as representing the mortality of the town in which the household was situate, or as an indication of the probable future mortality in similar households. But if we have 3.000 deaths in a population of 100,000 persons the death-rate of 30 per 1,000 may be accepted as closely representing the true death-rate of a population, of which the 100,000 is a fair sample and as an indication of what their future death-rate will be under similar circumstances. In stating a ratio, therefore, it is always important that the numbers upon which the ratio is calculated should be made known. In most cases conclusions derived from less than 100 units must be regarded as unreliable and only to be accepted provisionally, subject to confirmation. Those founded on 1,000 units are generally very close to the truth; and 10,000 units may be regarded as affording practical accuracy for most purposes.*

---

[*] The calculation of a percentage is an operation in "simple proportion." For example, in the first of the towns mentioned above 117 has to be calculated as percentage on 4,680 and $\frac{117 \times 100}{4,680} = 2{\cdot}5$ which is the required percentage. To reduce the smaller number to unity and the larger number proportionately, divide both by the smaller number. In the same example $\frac{117}{117} = 1$ and $\frac{4,680}{117} = 40$.

Ratios should not be founded upon two variable factors: one of the factors must be fixed and the other variable. It is a common error, for instance, to calculate infantile deaths as a percentage of total deaths, the correct method being to calculate them on the infantile population; and similarly, deaths from one disease should not be stated as a proportion to deaths from all diseases. Methods of this kind should, at all events, not be resorted to except for special purposes, and keeping in view the errors they involve. In the case of variable populations corrections can be made for differences of increase, diminution, or age constitution, so that their rates may be strictly comparable. In Indian statistics all ratios reckoned on population are more or less incorrect, because they are calculated on the *uncorrected* populations of the previous census.

Means.

The mean or average of a series of numbers indicating similar facts is a single number which is representative of the series or group.†

A mean not only represents a group of numbers by a single number, but it may afford a more or less trustworthy indication of future probabilities with regard to facts of the same nature. Generally speaking, the larger the number of members upon which the mean is calculated and the less they individually diverge from the mean the more valuable is that mean, whether as a representative statement of the facts indicated by those members or as a forecast of probabilities.

To judge of the value of a mean the extremes, that is the lowest and highest item represented by the mean, should always be stated. The extent of divergence, + or — from the mean, of the members may be expressed in percentages of the mean, and a mean may be usefully supplemented by a figure showing what proportion of the members of the series differ from it by a relatively small quantity. The *mean error* may be calculated by (1) finding the mean of all the members which are above the general mean of the whole series and subtracting the general mean from it, the + mean error being thus obtained; (2) finding the mean of all the members which are below the general mean, the — mean error being thus obtained. The two numbers added together and divided by two give the mean error.

---

* The degree of accuracy increases not directly, but as the square root of the number of observations.

† The *arithmetic mean* is the true mean for ordinary statistical inquiries. It is obtained by dividing the sum of the series by the number of members in the series. For example, the mean of 56, 32 and 41 is $\frac{56+32+41}{3} = 43$. In certain cases, however, the arithmetic mean is not correct; thus when the members of a series differ in "weight" (relative importance), the true or *geometric* mean must be obtained otherwise.

Fallacies of Average.—Supposing that each of the numbers upon which an average is computed be in itself reliable, and that those numbers be sufficiently numerous to yield a good average, yet the average may be a comparatively worthless and misleading expression, because the difference in the numbers is great. It may be that not only the extremes are great, but that none of the numbers is near the average. For simplicity we will take the average of two numbers; say that average is 50: the numbers on which it is founded may be very divergent, as 1 and 99, nearer, as 25 and 75, very close to the average, as 49 and 51, or even identical with it. Hence the advisability of stating extremes, and, if they diverge much from the average, of adding a statement showing the degree in which the numbers approximate to the average. The units composing an average may aptly be compared to the mark of rifle-bullets on a target; in the most valuable and representative average they will all be close to the centre, in a less valuable average they will be more or less scattered, extremes being perhaps very far from the centre, and in the least valuable kind of average they will be nearest to the margin of the target. We will now turn to some common errors in practical statistics connected with averages.

The average of ratios is often computed in a manner which is extremely erroneous, the average being reckoned on the mere ratio-numbers, forgetting that such numbers may differ largely in weight. The relative weights, for instance, of death-rates are in proportion to the relative numbers of the populations to which they refer.

If the populations are equal, the mean of their death-rates is the true mean death-rate of the whole; and, if the death-rates are equal, the same death-rate is true for the whole. But if the populations are unequal and have different death-rates the simplest method of calculating their combined death-rate is to reckon the rate on the sum of the populations and the sum of the deaths. For example, suppose three populations as follows :—

Population.	Deaths.	Death-rate.
24,780	510	20·6
30,615	649	21·2
101,912	4,159	40·8

The combined or average death-rate of the whole population is not the arithmetical average of the death-rates of its parts $\frac{20{\cdot}6 + 21{\cdot}2 + 40{\cdot}8}{3} = 27{\cdot}5$ but $\frac{5{,}318 \times 1{,}000}{156{,}370} = 34$.

A correct reckoning of *average strength* is important for obtaining true rates in the case of shifting and variable populations, such as those of troops, jails, schools, and works where the number of men varies. The average strength is the sum of the numbers present each day divided by 365, the number of days in the year.

In calculating annual rates when the population was present only a part of the year, the same rule must be observed ; for instance, if the place was occupied for only 160 days the sum of the daily population for these days must still be divided by 365 to give the average *annual* strength and the rates (taking the sum of the local events such as deaths) must be calculated on this to obtain annual rates. Rates should on no account be calculated on "total population," (*i.e.*, number present at the beginning of the year + admissions during the year). "A total population of 365 might mean 365 persons in residence throughout the year, or 365 entering on the last day of the year, or 1 entering daily." *

Objects of Statistical Enquiries.

The reasons for collecting statistics on matters concerning society are that exact information may be available to enable a right judgment to be formed of the influence of passing

---

* *Review of Bengal Jail Report,* 1885. *Indian Medical Gazette,* September 1886.

Death rate - Proportion of people dying compared to [illegible]
in Previous year

events such as scarcity, famine, war, commercial depression, epidemic disease, emigration and immigration on the prosperity of the community; and that it may be clear whether the sanitary and other enactments in force are tending towards good or evil. The aim of all sanitary measures is to improve the conditions of life so as to prolong the lives of a greater number of the population into the working period. Every baby born is equivalent to so much capital to the state, since it is potentially capable of so much work. This capital only becomes available after the individual has reached an age when he can look after himself, work, and contribute to the support of others. If his life be cut short before he has reached maturity the food, money, time and attention that have been expended in his bringing up and education are lost for ever to the community: the youth having died cannot make repayment in work. If his life end before he has reached middle age, he may have just repaid the sum invested in him by the community, but may not have contributed much to the general stock of wealth in his turn. If he live till old age compels him to cease from labour he will have contributed more to the community than was expended in rearing him, but if he live long, while old and unable to work, he again becomes a drain on the common resources. It is obvious then that every death in infancy is a direct loss to the community and that a still greater loss is incurred by every death in early manhood before life's work has well begun. It follows that every man who does no work, either mental or manual, is a dead loss to the community. This includes all persons who live idly on wealth accumulated by their fathers, and all beggars, and those who live on charity, doing nothing in return.

Arrangement of Statistics.

The method of arranging statistical facts is only second in importance to their correct compilation. The facts when intended for general use must be presented in a readily comprehensible form, because ill-educated persons, and even well-educated persons, who are unacquainted with statistical methods, will fail to draw correct inferences from figures which they understand imperfectly or improperly.

Statistical facts may be stated (1) numerically, (2) graphically, and (3) numerico-graphically. The first method consists of simple statements of numbers, such as sums, ratios, or averages.

The graphic method consists of the representation of statistical results by lines, spaces, colors, shading, etc. Thus lines of various length or spaces of various size may be drawn to scale in the ratios of numbers representing facts which it is intended to compare together, and such lines or spaces may be colored to distinguish them more vividly. The geographical distribution of certain facts may be shown by maps variously colored or shaded.*

The numerico-graphical method of arrangement is most frequently employed and most convenient for general purposes. It concludes the use of tables, curves, or lines combined with numbers, etc.

Fallacies of Comparison.—False inferences are very frequently made by comparing numbers which are not comparable, or which can properly become so only after corrections have been made. A few of the commonest errors are here noticed. Errors of comparison may arise in connection with primary numbers, ratios, or averages.

Primary numbers expressing certain variable facts in relation to other variable facts are sometimes wrongly quoted as though they were true ratios. It is obviously incorrect to compare totals (such as total deaths) affecting populations of different magnitudes; but it is also, though not so obviously, incorrect to compare totals affecting the same population at different periods. Thus an annually increasing number of deaths in a place does not at all warrant the inference that the place is becoming more unhealthy, nor does an annually diminishing number of deaths warrant the inference that a place is becoming more healthy; in the first case the population may be increasing, and in the second case it may be diminishing in a more rapid proportion than the deaths and its age-constitution may have changed. The use of primary numbers to express ratios is rarely justifiable; but they may often be usefully quoted to show the reliability of ratios calculated on them, or to impress persons unaccustomed to statistical inquiries with the magnitude of certain aggregate facts.

With regard to ratios errors are very often made by comparing the rates of differently constituted populations as to age and sex, or differing as to race, habits, occupation and wealth. *All* causes of variation should be kept in view when ratios are compared with regard to particular causes of variation. Ratios calculated on insufficient numbers or for very short periods must never be accepted as true, especially for comparative purposes.*

---

* Race or family characters of feature which are not readily amenable to numerical expression, may be averaged by superposing feeble photographic images of individuals so as to produce a single picture. (*F. Galton.*)

The more representative an average is, that is the closer its constituent members approach it, the more valuable it is for comparative as well as for other purposes. It is unsafe to compare averages of which the "mean error" is large or from which the "extremes" are very divergent.

POPULATION.

A correct knowledge of the composition of the population concerned is the first essential for statistical purposes. Exact information can only be obtained directly by a census.

Few populations, however, are stationary; it, therefore, becomes necessary to form estimates of population during the periods between censuses. This can be done accurately if complete returns of the number of births and deaths and of immigrants and emigrants are available; but in most places—practically all places in India—such returns are far too imperfect for the purpose.

Another method which gives generally correct results (and is employed by the Registrar-General of England) is therefore to be preferred. It is assumed that the rate of increase (or decrease) in a population remains constant, and the ascertained rate of increase during the period between two censuses is taken as the rate of increase during the next inter-censal period. Since the increments to population also increase, the calculation is evidently one of "compound interest".

The mean population of the year (*i.e.*, population calculated to the middle of the year) should be taken for reckoning annual rates, etc.

It may be observed that in Indian vital statistics all rates are calculated upon the *uncorrected* population according to the last census. A needless error, which increases every year after a census, is thus added to their admitted faultiness.

---

* The incorrectness of ratios on population as calculated in all Indian Vital Statistics is elsewhere alluded to. No allowance is made for increase or decrease, but they are reckoned on the population of the last census. The error thus tends to increase every year after a census and to render such numbers more incorrect, whether as mere statements of fact or for purposes of comparison.

The census of 1881 showed the population of the Madras Presidency to have decreased by 1·5 per cent. owing to the great famine of 1876–77. In 1891 it had increased by 15·5 per cent., a higher rate than the average, due to a rebound after the famine. The 1901 census showed an increase of 7·2 per cent. to have taken place which is probably about the normal rate.

Parts of the Bombay Presidency which had suffered severely from plague showed a decrease at the 1901 census.

The average annual rate of increase per 1,000 of population in the Madras Presidency as a whole is therefore between 7 and 8, and this may be used as rough basis for estimates of increase during the current inter-censal period.

Census.

The first census of India was taken in 1851, and thereafter quinquennial censuses were taken until 1871, when a decennial interval was adopted. Decennial censuses have been taken in England since 1801. A shorter interval would be advantageous, because estimates of population made many years after a census are aften erroneous to a considerable extent, and because it would conduce to greater accuracy of each census, the people being more accustomed to the inquiry, and a larger number of experienced persons being available as enumerators.

Besides a mere enumeration of the population, much valuable information as to its composition and its social condition is elicited by a well-planned census; and successive censuses exhibit the changes in a population. The following are the most important inquiries which are made: age, sex, occupation, conjugal condition, infirmities, number of inhabited houses, density of population. Of less importance, from a sanitary point of view, are education, religion, race, caste,* language, birth-place.

Age.—One of the most essential requirements in vital statistics is to know the age-composition of populations. Without any intentional misrepresentations two kinds of error have been found to prevail in age statements: the age of infants is apt to be over-stated, infants under one year being returned as one year old, under two years as two years old, etc., the infantile population thus tending to appear less numerous than it really is, and adults are apt to have their ages given in round numbers as 30, 40, 50, etc. Clear instructions and care on the part of enumerators ought to reduce the first error; the second is to a great extent obviated, by adopting age groups of 25–35, 35–45, etc.,* instead of 20–30, 30–40, etc.

---

* With regard to this subject the Report of the Madras Census of 1871 by W. R. Cornish, contains the most complete account which has been written.

The age-constitution of a population depends upon the birth-rate, death-rate, emigration and immigration. Emigrants are generally young adults; emigration, therefore, generally exerts an unfavourable and immigration a favourable influence on the age-constitution of the population. When the birth-rate of a population is continuously higher than its death-rate, the population not only increases, but its age-constitution is so affected that it possesses a larger proportion of individuals at the lower ages than a population which is not increasing or is increasing at a slower rate.

Populations of different age-constitution cannot be properly compared with one another unless due allowance be made for the difference. For instance—to take an extreme case, but one not unknown—it is absurd to compare, without correction for age-distribution, the mortality among a body of young people, such as school children, or of adults, such as workmen or troops, with the mortality of the general population. In comparing urban with rural populations, or even town populations with one another, differences of age-constitution should be taken into account if they be at all considerable. A knowledge of age-constitution is also very important in estimating the value of hygienic measures and for various other sanitary statistical purposes. In English statistics it is generally stated in quinquennial groups from 0 to 25, and decennial groups from 25 to 75, above 75 forming a single group.

The age-distribution of the population of the Madras Presidency at the census of 1901 is here shown per 1,000 persons living:—

---

* Farr.

All ages.	0–4	5–9	10–14	15–19	20–24	25–34	35–44	45–54	55 and over.
1,000	136	142	122	79	78	155	123	82	73

Note.—These figures are of doubtful accuracy.

This may be compared with the following table which gives the age-distribution of 1,000 persons in England and Wales in 1891 :—

All ages.	0–4	5–9	10–14	15–19	20–24	25–34	35–44	45–54	55 and over.
1,000	122	118	113	101	88	146	112	86	114

The economic value of a population largely depends upon its age-constitution : other things being equal in two populations, it is manifest that the one which possesses the larger proportion of individuals at working ages (15 to 50) has material advantage over the other.

Sex.—The sex-constitution of a population is important in particular cases when it differs much from the normal. The marriage, birth, and death-rates are influenced by it. In the Madras Presidency nearly 103 males are born for every 100 females born ;* but here as in every other country, the mortality of males at the earlier (under 5 years) and later ages (over 35) exceeds that of females, so that the population normally contains more females than males in the proportion of 102 to 100.†

Mixed populations differ so little from one another in sex-constitution that no correction need usually be made on this account when comparing of their death-rates, etc.

Occupation has very considerable influence upon health. As a rule, town and sedentary occupations have a deteriorating influence when compared with country and active occupations. Agriculture is the pursuit of the great majority of people in India.

---

* The mean corrected birth-rates, according to Mr. G. Stokes, being for males 43·11 and for females 41·90. The experience of the Madras Lying-in Hospital, however (1873–82) in 13,544 births, gives the proportion of male to 100 female births as before the famine 115, during the famine 98, and after the famine 111.

† According to 1881 census, also in 1901.

The following table * gives a comparison of the class-composition of the Madras and English populations :—

Class.	Madras.	England.
Professional	4	7
Domestic	1	3
Commercial	3	11
Agricultural	67	20
Industrial	19	49
Labourers, etc.	6	10
Total ...	100	100

The above classes should be largely sub-divided. To ascertain the effect of occupation on health, the mortality from different causes, as well as the total mortality, should be known. The mortality at different groups of ages should also be ascertained. In comparing the death-rates of persons engaged in particular trades or callings it must not be forgotten that persons are so employed during working ages, and that the age and sex-composition of the different groups is likely to differ largely and needs to be taken into account.†

---

* Madras Census Report, 1881.

† Doctor Ogle has prepared valuable occupational statistics for England, of which an extract is given in Newsholme's Vital Statistics, 1889. The following instances will suffice to show how much mortality is influenced by occupation. They indicate the annual death-rates per 1,000 of males (1880–82) :—

Occupation.	Age 25–45.	Age 45–65.
Clergymen	4·64	15·93
Farmers	6·09	16·53
Agricultural labourers	7·13	17·68
Builders and bricklayers ...	9·25	25·59
Carters and carriers	12·52	33·00
Inn-keepers and publicans ...	18·02	33·68
General labourers (London) ...	20·62	50·85

Conjugal condition.—The following figures are from the Madras Census Report, 1881. Of the total population $45\frac{1}{2}$ per cent. were single, 42 per cent. married and $2\frac{1}{2}$ per cent. widowed:—

—	Single.		Married.		Widowed.	
	Men.	Women.	Men.	Women.	Men.	Women.
All India	48	32	47	49	5	19
Madras	55	37	41	42	4	21
Madras over 15 years of age.	26·5	5·3	67·2	60·9	6·3	33·8
England over 20 years of age.	27·1	25·8	66·1	60·6	6·8	13·6

In Madras 173 per 10,000 men under 15 years of age were married; in England only 11 per 10,000 men under 20. In Madras 1,132 per 10,000 women under 15 were married; in England only 67 per 10,000 women under 20. In Madras only 5·3 per cent. of women over 15 were single, while in England 25·8 per cent. of women over 20 were single. These figures show that the difference between the conjugal condition of the people of India and that of the people of England (and other European countries) consists in the comparatively very early marriage of the former.* In England the average age at marriage (1887) is for men 26·2 and for women 24·7 years; and one-fifth of the people who attain a marriageable age never marry. In England the lowest, poorest, and the least educated classes marry earliest, and the socially highest and best-educated latest, the average age at marriage in the professional and independent class being 31·22 years for men and 26·4 years for women; but, even in the lowest classes, marriage is influenced by prudential considerations, and the marriages become fewer and later when prosperity diminishes. In India no prudential motives have, even in the educated classes, outweighed the power of custom, which enforces marriage at the earliest possible age.

---

* Some of the evil results of unrestrained early marriage have been already noticed. The ancient Greeks excelled in their admiration for, and cultivation of, physical perfection, and it is noticeable that Aristotle considered that men should marry at the age of 37 and women at 18, and Plato that men should be from 25 to 55 and women from 20 to 40.

The marriage-rate and age at marriage are most important as influencing the birth-rate of a population, the fecundity of early marriages being greater than that of later ones.* Earlier marriage must tend to increase population, even if the number of children to each marriage be not increased, for the intervals between generations will be diminished.

In a population where late marriage and a considerable amount of celibacy prevail, natural selection has much more important play in improving the race than in a population where all women marry at the earliest possible age and celibacy is practically unknown. In the former population many weakly persons die between the age of puberty and the usual marriage-age—persons who would have married in the latter population; and selection has considerable scope among those who survive, many remaining unmarried.

Infirmities.—The Census Report of 1901 shows that in the Madras Presidency out of every million of the population there were—

In	Insane.	Deaf-mutes.	Blind.	Lepers.
1871	446	1,313	1,946	441
1881	325	536	1,597	466
1891	215	760	1,022	353
1901	188	644	891	351

These figures are not very reliable, as friends are reluctant to publish such defects and enumerators cannot be expected to distinguish leprosy without fail.

In 1871 the proportion of lunatics was 1 in 2,222, the loss in 1881 being attributed to their greater mortality during the famine.

---

* Dr. M. Duncan found the average fecundity of women marrying at 15–19 years of age was 9·12, and it progressively diminished as ages advanced, being 4·6 for those marrying at 30–34 years. $\frac{\text{Births}}{\text{Marriages}} =$ mean fecundity per marriage.

The number of inhabited houses affords some indication of the extent of overcrowding in houses and a means of making future estimates of population. It is found that the mean number of persons per inhabited house remains fairly constant in the same population; enumeration of inhabited houses, therefore, affords a check on estimates of population at inter-censal periods, and it affords the best method—short of a census—for estimating the number of a population which has been much affected by migration.*

Overcrowding in houses is no doubt a great cause of disease and death; but it must be borne in mind that the greatest overcrowding occurs among the most indigent, who live in other respects also under the most insanitary conditions.

Density of population for general or country populations is usually stated as number of persons to each square mile, and for towns as number of persons to each acre. It may also be reckoned by making area the variable factor and calculating the number of acres or square yards to each person.†

The number of persons per square mile in the Madras Presidency according to the census of—

1871 was 227.
1881 ,, 221 (Famine, 1876-1877).
1891 ,, 253.
1901 ,, 270.

In 1901 the extremes were Tanjore 561 and Kurnool 115.

In 1881 the average in Bengal was 457, North-West Provinces 416, Burma 43, England 447.

In country districts the density of population has usually little or no effect on health and mortality. In India indeed increased density in country districts may conduce to an improvement of public health by causing the removal of unhealthy scrub and the cultivation of waste lands.*

---

* In 1901 the average number of persons per occupied house in Madras City was 9. The average for the whole Presidency was 5.

† $\frac{\text{Population}}{\text{Area}}$ = mean population per unit of area, and $\frac{\text{Area}}{\text{population}}$ = mean area to each person.

It is in towns that density of population has particularly obnoxious effects. The following statements may be taken as axioms : (1) Other things being equal, the bigger the town in population, the greater is its mortality, and (2) other things being equal, the larger the town in area, the less is its mortality.

In towns many causes of disease exist from which villages are comparatively free. The poor and the dissolute are attracted to towns in search of food, or money, or dissipation. Temptations to the adoption of unhealthy practices are greater. Every nuisance and every case of communicable disease becomes a greater danger as the population is larger. Cleansing is more difficult, and, if it is not well performed, pollution of soil and air are more extensive. If there be no public water-supply from without, the contamination of drinking water is greater. Different classes are apt to congregate in different localities; and thus the poorer quarters of large towns teem with a concentration of vice, misery, filth, and disease. To all these and other evils are dwellers in towns exposed ; and we need not wonder that they should generally suffer from sickness and mortality to a larger extent than do the inhabitants of villages.

But the inhabitants of towns have some great sanitary advantages ; and, when they have the knowledge and energy to use these advantages, they may rival or surpass countrymen in healthiness.†

If poverty tends to concentrate itself in towns, so does wealth tend to accumulate in them. If large communities breed dirt, so do they afford means for its removal ; if they harbour pestilence, so can they combine to suppress it. They can command skilled advice and the means for acting upon it. They can bring pure water from a distance, or build works for its purification; they can construct and maintain well made sewers, drains, slaughter-houses, latrines, markets, hospitals for infectious diseases, cremation or burial places, and sewage-farms, and can manage a public system of cleansing and lighting. They can make and enforce regulations as to the sanitary construction and maintenance of houses, the sale of wholesome food, the isolation of infectious diseases, and many other matters connected with the public health and well-being.

---

* I may here take exception to a statement in the Madras Census Report 1881 (Appendix A), that in the Madras Presidency there is no rural population properly speaking, that is dwelling in detached houses. "Every village is as closely packed, as unclean, and as prejudicial to health as the largest city." The majority of the rural population in all countries dwell in hamlets and villages ; and, lamentably bad as is the sanitary condition of Madras villages, I do not think they can be compared, as to filth and overcrowding, with the very poor quarters of large towns. They certainly have the great advantage of comparatively pure air outside the houses. Statistics, so far as they go, indicate that in India as elsewhere rural populations are healthier than town populations in almost every respect except their greater liability to malarial infection.

† The considerable reduction of mortality in England in recent years has been due almost entirely to sanitary improvements in towns.

Large towns may thus do much towards sanitation, which is beyond the knowledge or the means of individuals or of small communities; and, with vigorous administration and the assistance of loans for large public works, Indian municipal towns ought to make rapid strides in reducing their present unhealthiness.

Registration of Births and Deaths.

An accurate registration of births and deaths, with subsidiary particulars, is as necessary to the sanitary statist as an accurate knowledge of population obtained by census.

In India generally such registration has hitherto been extremely imperfect and unreliable. Recent legislative enactments, if enforced, will no doubt improve it in municipal towns; but it will be long before district registration can become satisfactory. In the city of Madras, registration is compulsory under a penalty of Rs. 20 for default (section 402, Madras Municipal Act, 1883). In the District Municipalities Act, 1884, though provision is made for registration, there is no penal clause; but a penalty may be provided for in bye-laws under this Act. In the Local Boards Act, 1884, the subject of registration is not mentioned.*

So long as registration of births and deaths is imperfect, it will be impossible to form exact judgments as to the sanitary needs of communities and as to improvements in their condition.

---

* District registration is performed by village headmen. It ought to be regarded as a very important part of their duties; and, if severe notice were always taken of its neglect, district returns would be much better than they are. When the registered death rates are below 30, and birth-rates much below 40, defective registration may be suspected.

The most necessary particulars required in registering births are date, sex, nationality or caste, profession of father; and in registering deaths, date, age, sex, cause of death, profession, residence.*

Still-born children should not properly be included in either the birth or death registers, but a separate register of them should be kept.

The *cause of death* is a very important particular, and one which it is often difficult to obtain with accuracy, even in countries where registration is otherwise good. The reasons for this are difficulties in the classification and nomenclature of diseases and faulty diagnosis. When causes of death cannot be ascertained by registrars, they should be marked "not known."

Births.

The actual registered birth-rate in the Madras Presidency averages 30 per 1,000, but there is good reason for thinking that in reality it is well over 40 per 1,000. In Madras City where birth registration is fairly good, though by no means perfect, the birth-rate is generally near 40 per 1,000. The annual birth-rate of a community is calculated according to the subjoined formula:

$$\frac{\text{Number of births in one year} \times 1{,}000.}{\text{Population}}$$

Weekly birth-rates are calculated thus—

$$\frac{\text{Number of births during one week} \times 52{\cdot}17 \text{ (number of weeks in 1 year)} \times 1{,}000}{\text{Population}}$$

In this case the meaning of the figure obtained is that, if the same number of births which occurred in that week continued to occur every week throughout the year, the rate would be so and so.

Similarly, calculations can be made for monthly and quarterly periods.

---

* *Vide* forms prescribed in Schedules L and M of Madras Municipal Act.

In comparing the birth-rates of two populations, their age and sex composition must be taken into account if they differ much. An approximate correction for differences in age and sex composition may be made by calculating the birth-rates on the female population at child-bearing ages instead of on the general population.

Causes which increase the birth-rate are early marriage, favourable age-constitution of population (a large proportion of the women being of child-bearing ages), favourable sex-constitution of population (the normal proportion, or, in polygamous societies, an excess of women), and abundance of food.

* In India, since all women practically begin child-bearing at the earliest possible age, the birth-rate is always the highest possible; and were it not for the high rate of mortality, especially the enormous infantile mortality, the population would increase at an extremely rapid rate † —a rate impossible in a settled, populous, and mainly agricultural country, for the means of subsistence could not increase so fast.

As a matter of fact the doctrines of Malthus do apply very closely to Indian populations. These populations constantly tend to increase up to the limits of means of subsistence. In prosperous times they increase very rapidly; and, having no reserve of means, when hard times come, they succumb by millions. A large proportion of them live habitually in a condition of semi-starvation. Pestilences are always rife among them. Insanitary conditions slay the great majority of their children—children who should never have been born—whose lives, before and after birth, are a useless drain on the strength and resources of their parents.

People, like this, who multiply after the manner of wild animals and plants, cannot but share the fate of wild animals and plants: "each, at some period of its life, during some season of the year, during each generation or at intervals, has to struggle for life and to suffer great destruction."‡ Improvement is difficult while such conditions endure, except that low form of improvement—or degradation—consisting

---

* I cannot entirely subscribe to the views expressed by the author in some of the following paragraphs, but I do not on that account feel justified in omitting them from the text, as opinions, and not facts, are in question.— J.W.C.

† It would double itself in 29 years if the rate of mortality were the same as the English rate.

‡ Darwin: *Origin of Species.*

in adaptation to, and survival of the fittest to live under, depraved circumstances.

This excessive (highest possible) birth-rate is the greatest obstacle to sanitary improvement in India. While the people continue to beget more children than they can rear * or the country can support, chronic poverty, with its concomitants of dirt, disease, and famine must prevail among them. It is no doubt true that sanitary measures may, in some places, largely reduce the present high mortality. But what must be the effect of such a reduction of mortality while the present birth-rate continues? What must be the effect of a too rapid rate of increase in the population of agricultural and already fairly populous countries?

Supposing only a comparatively small decline in the present death rate were to take place throughout the country, the continuance of the present birth-rate would cause the population to increase at the same rate as that of the English population, a manufacturing and emigrating population with a large reserve of accumulated wealth and the "prudential check" of later marriage when prosperity diminishes. And will agricultural India be able to feed double her present population even fifty years hence? With the present birth-rate, will not a diminution of mortality in one place mean increased poverty and mortality later on, or else migration and increased poverty and mortality in other places?

Does not this inelastic and extreme birth-rate, which is controlled only by famine, prevent any material reduction in the general death-rate of the country?

It may, I think, be laid down as a general axiom that the increase of a healthy population is governed by its birth-rate; that is, the death-rate, having been reduced by good sanitation to nearly its lowest possible level, remains nearly stationary, but the birth-rate is kept under rational control † and is the changing factor which regulates the rate of increase of the population in proportion as circumstances

---

* It is a constant occurrence that men in search of employment or promotion declare themselves to be "poor men with large families," and this is generally true. In populous countries poor men have no business to have large families—their having them is a social crime and the origin of much misery. A man might as logically ask for assistance because he has lost his health by intemperance in drink or food or been beggared by gambling as because he had begotten a large family. Pity for the children may be laudable—their self-indulgent and reckless parents deserve none.

† In England half the women of child-bearing ages are unmarried, and the births are thus kept down to half their possible number.

favour such increase, and may cause the population to remain stationary or to decrease when conditions become less favourable. In India the increase of the population is governed largely by its death-rate, this being the more variable factor, while the birth-rate remains comparatively stationary. In the former case the "prudential check" (of Malthus) comes into play, that is, the increase of population is regulated by reason; in the latter the "misery check" holds sway, that is, the increase of population is restrained by nature.

Certain variations in Indian birth-rates do occur, however; and they are due mainly to the same causes which produce natural variations in the death-rates (apart from sanitary improvements), namely, abundance or deficiency of food. Abundance of food increases the procreative power and deficiency diminishes it. Prosperity, therefore, tends to a rapid increase of population by acting in two directions, raising the birth-rate and lowering the death-rate; while, conversely, adversity puts a double check on population.*

The early marriage question is at the root of the terribly high birth-rates which thwart sanitation in India, and of the poverty and much of the unhealthiness in which Indian populations are plunged. This is a social question and one for agitation among the people themselves. Native philanthropists have here in truth a large evil to engage them, and one which is worthy of their most strenuous and persevering endeavours to alleviate.†

---

* An Indian population is more sensitive than a European one, both to prosperity and to adversity, because in the former there is always a large proportion of persons in want or on the verge of it, and all women of child-bearing ages are already married.

† In considering the effects of this continuous highest possible birth-rate, one might well feel disposed to adopt the most pessimistic views of Malthus or of the Secretary to the Punjab Government (Review of Sanitary Report for 1885), or to feel the unintended satire in the advice of a late high official who recommended the people to become rich!

But the author is hopeful as to the gradual sanitary amelioration of the peoples of India; he is hopeful that, as sanitary improvements are effected, so will reasonable views as to marriage and propagation take root in the upper and spread to the lower classes, that the birth-rates will be brought more under control, and that they will diminish *pari passu* with the death-rates.

At the same time he feels convinced that until the effect of the very high birth-rate as a block to sanitation is fully recognised, and until births begin to diminish, no great reduction of the general death-rate is possible throughout the country. A sudden reduction of the birth-rate is not to be expected; nor is it to be desired, because under present insanitary conditions (which cannot be very rapidly ameliorated) the population might easily become a diminishing one and unhealthy tracts of country would be depopulated.

Early marriage increases the birth-rate in three ways: 1 - by producing a larger number of children per marriage, by 2 - diminishing the intervals between generations, and by producing a favourable age-constitution of population.

Birth-rate and age-constitution exert a mutual influence upon each other. A continuously high birth-rate produces a population containing an excessive proportion of youthful and young adult members; and such a population is naturally productive of a high birth-rate, especially in India, on account of the early and general marriage of girls. A favourable age-constitution produced by other causes, such as a migration of young adults to a town, or a high death-rate, tends similarly to increase the birth-rate.

Deaths.

The registered death-rate for the whole of the Madras Presidency during 1900 was 23·4 per 1,000. In municipalities and towns the rate was 32·6 per 1,000, and in districts excluding towns 22·6 per 1,000. Owing to defective registration these numbers are almost certainly short of the true figures. In Madras City where death registration is not liable to much error, the average rate for the 10 years ending with 1899 was 40·8 per mille. This is the uncorrected rate, no allowance having been made for increase of population. The rate for 1899 calculated on the 1891 census was 38·1 per 1,000, but calculated on the estimated population in 1899 it falls to 34·4 per 1,000. This is called the corrected death-rate.

The annual death-rate of a place is calculated in a precisely similar way to the birth-rate.

$$\frac{\text{Number of deaths in one year} \times 1{,}000}{\text{Population.}}$$

= Death rate
in one year

Large fluctuations in death-rates for short periods may be due to climatic causes, epidemics, or diseases which have a marked seasonal prevalence Short period rates should be reckoned only for large populations; else they are unreliable owing to an insufficient number of data. Weekly or monthly mortality statements are of great value for indicating sanitary changes which may not be evident and for estimating those which are evident. "The deaths serve the purpose of a self-registering inspection." (Farr.)

The general death-rate of a population is the most commonly employed test of its sanitary condition, and it is generally a reliable test.

The sensitiveness of Indian death-rates to sanitary conditions is remarkable, and their fluctuations are greater than those of European populations. * This sensitiveness may be attributed to several causes : (1) the low age-constitution of the population, which naturally favours a low death-rate ; (2) the high birth-rate, infantile mortality forming a large proportion of general mortality and being notoriously sensitive to sanitary conditions ; (3) the early marriage of all girls, which causes the population to breed up to its means of subsistence and renders it easily and extensively affected by want ; (4) the high death-rate, which is more easily and largely affected by favourable conditions than a low death-rate and conduces to a low mean age of population. Large fluctuations are commonly due to epidemics of cholera or small pox, to outbursts of malaria and times of scarcity.

Special death-rates applied to separate causes of death and to separate sections of the population are of the greatest use in sanitary investigations. They show the effect of diseases, or of age, sex, occupation, locality, &c., on mortality, and by revealing the causes or particular incidence of high death-rates may enable defects to be pointed out and the efficacy of remedies to be estimated. A few of the more important special death-rates are noticed below.

The death-rate at different ages is a very important sub-division of the general death-rate. The presence of insanitary conditions, or of diseases which affect life at different periods, are thus made evident. Since the age-constitution of different populations may vary considerably, it is important that age-mortality should always be reckoned on the population at different age-groups and not (as it is

---

* The following are examples :—

Towns.	1884.	1885.	1886.	1887.	1888.
Madras	49·4	36·4	36·1	39·4	37·8
Cuddapah	41·8	24·7	31·7	48·9	37·1
Coimbatore	27·9	35·9	36·6	38·2	29·3
Trichinopoly	25·6	29·5	22·9	35·8	30·9

Some places show much larger differences, but as the rate increases progressively, these may be mainly due to defective registration.

frequently and wrongly) as a percentage of total deaths; and the variations of the latter constitute a further reason for reckoning the deaths at particular ages on the population at those ages. The infantile (under 1 year) death-rate is best reckoned on the births of the year.

To show the varying mortality in different age groups the following tables are inserted:—

Mean annual rate of mortality in England and Wales per 1,000 *of each sex*, 1891–1895.

—	Males.	Females.
All ages.	19·8	17·7
Under 5	62·1	52·0
5–9	4·5	4·5
10–14	2·5	2·7
15–19	4·0	4·0
20–24	5·3	4·9
25–34	7·2	6·7
35–44	12·2	10·3
45–54	19·8	15·3
55–64	36·3	29·8
65–74	71·9	62·8
75–84	149·9	136·1
85 and upwards ...	290·6	263·8

37·5

Rate of mortality in Madras City per 1,000 *of each sex in* 1900.

—	Males.	Females.
All ages	46·9	45·5
Under 5	171·7	151·7
5–9	20·3	19·8
10–19	13·6	16·7
20–39	21·0	21·3
40–59	38·2	30·7
60 and over	124·1	138·5

92·4

Neither birth-rates or death-rates can fairly be compared in different towns or communities unless corrections be made for the age and sex distribution of the populations.

Men must die and their age is limited; so it is impossible for the death-rate to drop below a certain figure even in the healthiest and best managed town. A death-rate of 10 per 1,000 means either that every child born lives to 100 or that if some die before attaining that age others must greatly exceed it. If the span of life remains at about its present length, in a town with an average age and sex distribution we cannot expect the death-rate to touch a much lower ratio than 15 per 1,000. In the tropics where conditions of life are not so favourable as in temperate climates, it is probable that a death-rate of 20 per 1,000 will never be improved upon.

Infantile mortality is the ratio of deaths under one year to 1,000 births. It should not be calculated either on the general or infantile population. Other things being equal the infantile mortality is regarded as a most reliable indication of the sanitary condition of a town or district. In 78 English towns taken together the infantile mortality in 1895 was 160. In 1899 the infantile mortality in Calcutta was 366 per 1,000 births, in Bombay 786, and in Madras 272.

The above tables show (1) that mortality differs very much at different ages, being much below the general rate between the ages of 5 and 45, and much above it under 5 and over 55; (2) that the mortality of the sexes shows sensible differences, the general death-rate of males being considerably higher than that of females, the male mortality being in excess under 5 and over 20 in England, and under 10 and over 40 in Madras. Consequently the death-rate of a population will be lowered by an increased proportion of persons aged 5–45 and of females, and conversely.

The excessive male mortality under 5 occurs almost entirely in infants and is attributable to the larger size and more difficult birth of males. The higher female mortality from 10 to 20 may be partly attributable to diseases of puberty, and it is undoubtedly increased by too early marriage; it is much higher proportionately as well as actually in Madras than in England. The excessive and increasing male mortality over 20 in England is apparently due to the greater hardships of men's lives.

Correction of death-rates for age and sex is manifestly necessary for correct comparison of the death-rates of different populations. In most mixed populations the proportion of sexes is so nearly equal that it is unnecessary to make any correction for sex; but in special cases it must be made. In comparing the death-rate of the population of the same place at different periods correction for age also is rarely required, because, in the absence of violent disturbing causes (as famine or migration), the age-constitution is not liable to rapid change. In mixed populations differences of age-constitution rarely occasion a difference exceeding 3 in their death-rates per 1,000. When the difference is much larger than this, correction for age is never likely to reverse the position, though it will state it more accurately.* It is in the case of special death-rates, such as those of troops or schools, that corrections for age and sex are most necessary, often essential, for comparative purposes.

The effect of public institutions, such as hospitals, jails, or lunatic asylums, in towns may be to perceptibly increase the death-rate. Persons in such institutions who do not belong to the place may properly be excluded from the general statistics of the population. Places resorted to by pilgrims or other strangers may similarly have their death-rates affected if the deaths of such persons are included. On the other hand the presence of a considerable number of young students, or troops, or the influx of young adults into a town may lower its mortality. These, however, are taken into account in giving the age-distribution of the population.

The relation of birth-rates to death-rates is very important. Owing to the almost constant coincidence of high birth-rates and high death-rates, they have been by many authorities regarded as cause and effect. Their true relationship was expounded by Dr. Farr, who pointed out that a continuously high birth-rate naturally tends to produce an age-distribution of population which is favourable to a low death-rate, that is to increase the proportion of persons living at the lower ages (5–45) whose death-rate is naturally low.

The first effect of an increased birth-rate (*i.e.*, for first five years) must, however, be always to increase the death-rate, owing to the increase of the infantile population among whom mortality is high.

But it cannot be doubted that a continuously high birth-rate in a population, when, owing to any cause, such as improvidence, idleness, ignorance or density of population, means of subsistence do not or cannot increase with commensurate rapidity, must cause indirectly a continuously high death-rate. In other words the "misery-check" of Malthus must come into play. Ill-nourished mothers beget starveling children and suckle them with milk which is deficient in quality † and quantity; the infant mortality is thus easily increased, and poverty, overcrowding, and deficient food foster other insanitary conditions and conduce to a high death-rate at other ages. In these ways a high birth-rate does practically cause a high death-rate, although, at the same time, it may produce an age-distribution of population favourable to a low death-rate.

---

* For further information on all subjects connected with vital statistics Dr. A. Newsholme's book on this subject may be consulted.

† Analyses of *famine-milk* were made by the late Mr. W. Hamilton and show *great* loss in this respect. Cornish: *Sanitary and Medical Aspects of Famine.* Appendix I, Report, Sanitary Commissioner, Madras, 1877.

Causes of death.—Statistics showing the causes of deaths are evidently of the greatest value for ascertaining the sanitary condition of a community and indicating removeable insanitary conditions. In India for statistics of the general population the four principal causes of death alone are distinguished, two of these causes (cholera and small-pox) being specific diseases, and two groups of diseases (bowel-complaints and fevers). The fevers, however, are almost all malarial. All deaths not included under one of these four causes are grouped together as "deaths from other causes," except deaths from "injuries", which are distinguished into deaths caused by (1) suicide, (2) wounds and accidents, (3) snakes and wild beasts.

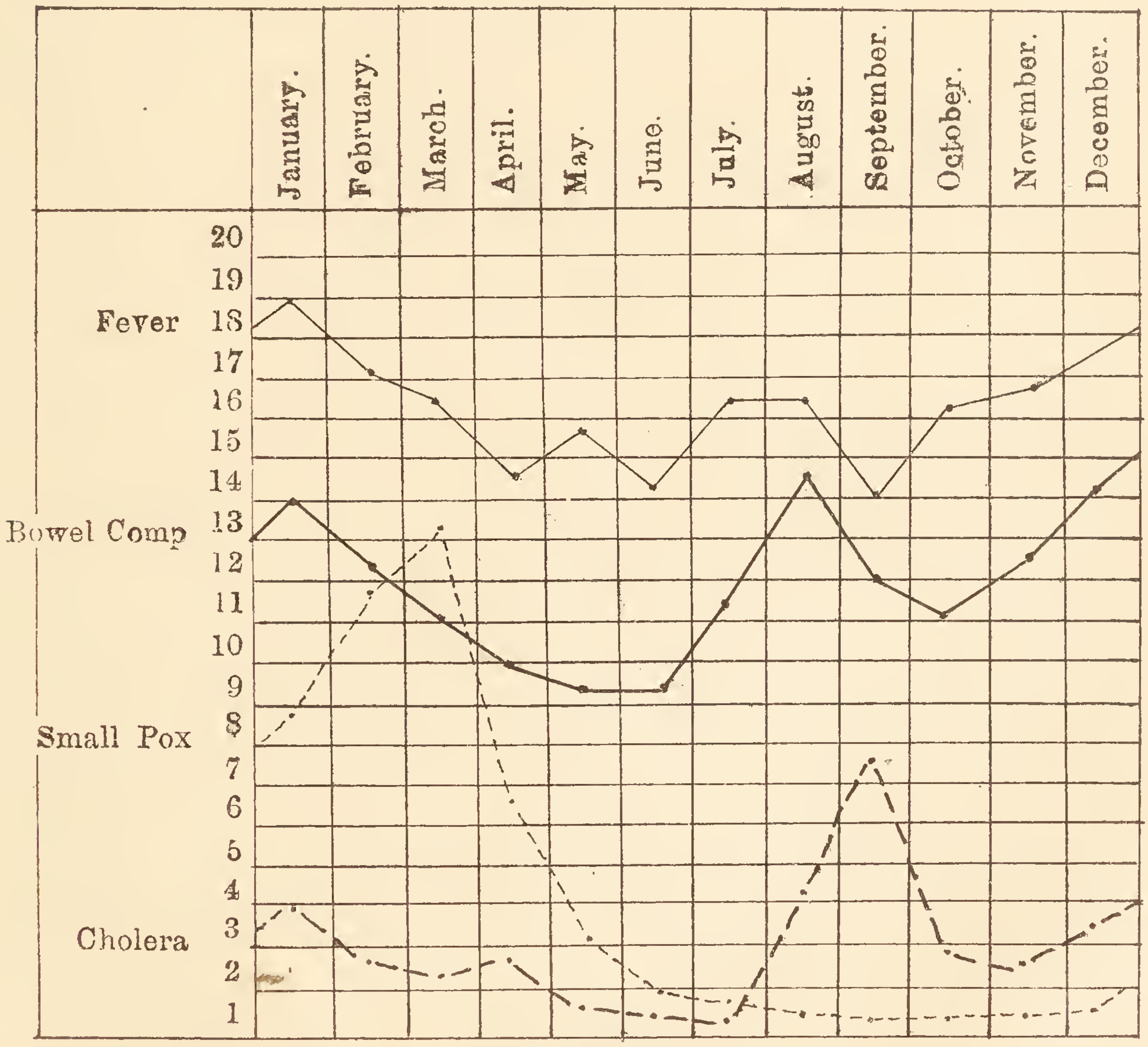
Medical returns from hospitals, jails, and troops give a classification of deaths according to the *Nomenclature of Diseases* compiled by a committee of the Royal College of Physicians, London. This was founded upon, but differs in some respects from, the Registrar-General's method of classification. Classification of diseases is not, however, a question to be discussed here; what is of more immediate importance to us is the nomenclature of diseases; and in registering causes of death, it is important (1) to use only the names contained in the official nomenclature, and (2) to state the remote, rather than the proximate, cause, for instance death from pneumonia during an attack of measles should be returned as death from measles.

A complete and reliable registration of causes of death is impossible, unless all the deceased were attended or examined by competent medical men who can certify the causes. The time is approaching when such a registration may be attempted in some of the more advanced towns: at present it would be impossible. Some diseases occur only at certain periods or life, or prevail especially at certain periods. The mean age at death from such diseases is of medical interest, and the prevalence of such diseases in connection with the age-constitution of a population is of sanitary and statistical importance.

Deaths according to locality form an obviously useful distribution of the general death-rate, and may often serve as an indication or as a measure of local causes of unhealthiness. Local death-rates in districts of large towns may be employed for this purpose. The geographical distribution of endemic diseases and the course of epidemics may be traced with accuracy by local death-rates ; and useful knowledge regarding their causation and prevention may thus be gathered.

Deaths according to occupation should be recorded by registration.* Occupational mortality has been already alluded to under the head of *Census*. In comparing the death-rates of different populations the possible influence of differences in their occupations should be borne in mind.

Deaths according to season give many useful indications, especially when deaths from special causes are so recorded. The following statement exhibited the seasonal mortality in Madras town from the four principal causes of death in the five years 1884–88. It is remarkable that the fever deaths show uncommonly little variation :—



The thin horizontal lines indicate hundreds of deaths up to 2,000.

---

* A column for profession is contained in the form prescribed by the City of Madras Municipal Act.

SICKNESS.

Registration of sickness has hitherto been found impossible for the general population anywhere. It has only been effected in the case of public services, companies, societies, and institutions. From statistics of sickness thus obtained more or less trustworthy estimates of sickness among the general population may be framed when we possess good mortality statistics. Dr. Farr estimated that in England for every annual death which occurs, two persons are constantly sick; in other words, for one death there are two years of severe sickness.

DURATION OF LIFE.

Although the duration of an individual life is proverbially uncertain, yet the average duration of life in a large community of men is subject to very little fluctuation.

This is evident from the following figures which are also held to indicate the influence of improved sanitation and better conditions of life generally on the national prosperity. In England the expectation of life at birth of males

Between 1838 and 1854 was 39·91 years;
,, 1871 and 1880 ,, 41·35 ,,
,, 1881 and 1890 ,, 43·66 ,,

so that during the period of 52 years between 1838 and 1890 the average national life increased in length 3·75 years, and this, if an addition to the working years of a man's life, means a vast increase of wealth to the State. On the other hand, if it merely means that the improved conditions have resulted in saving the lives of infants and unhealthy individuals for a few years, who would otherwise have died, it is obvious that the improvement has not yet gone far enough, that the State has only succeeded in burdening itself with a number of useless lives which are not sufficiently prolonged to reach into the period of working years. That the latter view is the correct one is supported by the fact that the expectation of life for adults over 26 years of age is now actually less than formerly.

Life tables

are the only exact means for ascertaining the duration of life and the probabilities of death at birth or at subsequent ages. They are founded upon the number and ages of the living and the number and ages of those who die in a population, and represent "a generation of individuals passing through time."

A life-table population (which is of course hypothetical) consists of a number of individuals born at the same moment, and whose course through life is traced, the number dying in each year being recorded. Its statistics, therefore, are free from the errors attending those of changing populations.* Owing to the differences of male and female mortality separate life-tables for each sex are commonly prepared.

The principal indications obtainable from a life-table are: (1) age or past life-time; (2) annual mortality at each age; (3) probability of living one year from each age; (4) number born and living at each age; (5) mean population in each year of age; (6) years which the persons at each age will live; (7) mean after life-time at each age.

The mean duration of life,

which is the most reliable test of sanitary state, is identical with *the mean after life-time from a birth or expectation of life.*

When no life-table is available *the mean duration of life* may be obtained approximately from the birth and death-rates by the use of Farr's formula $\left(\frac{2}{3}\times\frac{1}{d}\right)+\left(\frac{1}{3}\times\frac{1}{b}\right)$ — b being the birth-rate and d the death-rate per *unit* of population. For instance the corrected Madras birth-rate (as given by Mr. Stokes) is 42·4 and the death-rate 33·7; therefore $\left(\frac{2}{3}\times\frac{1}{\cdot 0337}\right)+\left(\frac{1}{3}\times\frac{1}{\cdot 0424}\right)=27{\cdot}6$ years, which is the approximate mean duration of life in a Madras population. In England the mean duration of life is 43 years.

---

* For methods of construction of life-tables Dr. Farr's *Vital Statistics* or the chapter on Life Tables in Dr. Newsholme's *Vital Statistics* may be consulted. Mr. G. Stokes has prepared a Madras Life-Table, but the data on which he worked were very imperfect.

CHAPTER XII.

SANITARY LAW.

THE first duty of the State is the protection of life. The protection of health is a closely allied duty. Immeasurably more destruction of life, more misery and greater economic loss are caused, even in the healthiest countries, by the incessant attacks of preventable diseases than by the most disastrous wars or the most widespread brigandage. Reasonable persons, who at once admit the necessity of State legislation and taxation to secure the blessings of internal and external peace and as much individual freedom as is compatible with the general weal, yet are often blind to the necessity of legislation and taxation to protect their lives and their health from death and disease.

This is the blindness of ignorance; and unfortunately sanitary legislation cannot be thoroughly effective if it is too far in advance of popular ideas. Sanitary legislation must therefore be accompanied by a better knowledge of sanitary principles on the part of the public, especially the educated classes, as well as on the part of legislators and administrators. In England "the success of the Public Health Acts, 1872–75, has been very great and . . . . . . has been progressive from year to year. The reason is obvious . . . . wise and moderate provisions were loyally accepted by the public."*

In India sanitary legislation must of necessity be greatly in advance of popular ideas and education, and be sometimes opposed to old-rooted prejudices and time-honored habits; and those who possess a modern education are not always those who have most influence with the illiterate masses. Here therefore the difficulties of the sanitary legislator, and far more the difficulties of the sanitary administrator, are immensely increased.

---

* W. Carter, *M.D.*, *LL.B.*, B.M.J., 1884.

To ensure the success of a sanitary law the people must in some measure be educated up to it, so that they shall have an idea of its purport. The great value of *permissive legislation* is that it thus paves the way for more stringent and effective laws.

Recent Indian legislation has conferred very extensive powers upon local bodies. Until these bodies have shown themselves capable of wielding such powers efficiently, and the people more fully recognise their value, there can be little need for more extensive powers. Lacking, as we do, and must do for a long time to come, a sufficient number of properly-educated sanitary administrators, efforts should be directed to their training, and to the sanitary education of the people under them, as the best means of rendering present laws effective. Heretofore these laws have been, as a rule, notoriously ineffective.

The main purposes of sanitary legislation are—

(1) to protect individuals and communities from injury to health by their neighbour's faults (including necessarily restriction of their own malpractices);

(2) to make provision for the joint execution of large sanitary enterprises.

The following abstracts of those parts of local Acts which deal directly with sanitation may be found useful for reference:—

THE CITY OF MADRAS MUNICIPAL ACT.

(*Madras Act I,* 1884, *as amended by Madras Acts VII of* 1884 *and II of* 1892.)

Sect. 34. The entire executive power and responsibility . . . shall be vested in the President assisted by the officers appointed under section 37 (these officers are styled the Revenue Officer, the Health Officer, and the Engineer).

39. The Health Officer shall be in charge of the conservancy and sanitation of the city.

41. A special Sanitary Officer may be appointed to investigate the causes of any epidemic or unusual mortality.

64. Government may compel the Commissioners to perform duties imposed on them by this Act.

138. *et. seq.* provide for the levy of a water-tax on buildings and lands.

Sect. 145. Waste or misuse of water punishable by fine of Rs. 20.

212. The Commissioners must provide a continuous supply of wholesome water and erect standpipes, fountains, reservoirs or pumps, at such distances that, in the populous parts of the city, no house shall be further than 150 yards from one.

213. Water may be supplied to buildings.

215. Supply channel to be fenced.

216. Penalty of Rs. 20 for trespass on premises connected with water-supply.

225. Fouling of water by offensive trades punishable by a fine of Rs. 1,000, and Rs. 500 each day for continuance of offence.

227. Commissioners may provide or set apart bathing places and tanks or reservoirs or runs of water for washing animals or clothes.

228. Whoever in any manner fouls any public or private source of drinking-water is punishable by a fine of Rs. 50.

229. A fine of similar amount is leviable for washing an animal or clothing in a place set apart for bathing; or for washing cooking utensils, wool, skins or other foul or offensive substances in a place set apart for washing clothes or for bathing, or polluting such water with any filth.

230. Owner of private tank, well or other source of drinking-water may be required to keep and maintain it clean and in good repair.

231. Owner may be required to close or fence a well or tank, the water of which is unfit for drinking.

232. On refusal the President may execute the needful works.

233 *et seq.* treat of the construction, paving and repairing of streets.

254. Commissioners to provide and maintain a system of drainage.

258. Drains and sewers must not be a nuisance or injurious to health.

259. Sewage may be conveyed to convenient dépôt and may be sold.

261. No building to be erected over a sewer without the consent of the President.

265. Notice to be given to the President of any new building or restoration, with plan of dimension and of ground floor, statement of means of ventilation, drainage and privies, and such further particulars as may be required under bye-laws.

Sect. 266. In case of disapproval President to state his views.

267. A building or well begun without due notice or materially deviating for the sanctioned plan may be ordered to be altered or demolished.

271. No block of six or more huts may be built without the permission of the President, who may require such huts to be built in a regular way and with due provision for sanitary requirements.

273. The President may compel the owner of any building which is not properly drained to drain it into a public sewer or drain, if such be within one hundred feet.

277. All branch drains, private privies, cess-pools, etc., shall be under the control of the Commissioners and be kept in order at the cost of owners. In case of neglect President may cause work to be done and recover expense.

280. Every owner or occupier of a building or a block of six or more huts must provide and maintain such latrines as the President may direct, under a penalty of Rs. 50 and Rs. 10 per day for default.

281. A similar penalty is imposable for not providing and maintaining proper latrines and urinals in places where over twenty workmen are employed.

304. President must provide for regular cleansing of streets.

306. And suitable rubbish dépôts.

307. And sufficient dust-bins in the streets ; for the reception of ashes, kitchen-refuse and other inoffensive matter. Building, stable and garden-refuse must be removed by the owner. Penalty of Rs. 10 for deposit of rubbish except in dust-bins.

308. Night-soil to be removed in covered vehicles and dépôts provided for it.

309. The President may require all occupiers of buildings to provide moveable private receptacles of a specified kind for night-soil.

313. Penalty for keeping filth on premises more than 24 hours, Rs. 50 and Rs. 10 for each day.

314. Penalty of Rs. 10 for allowing sewage to flow into street.

317. Penalty of Rs. 50 for throwing rubbish into or obstructing sewers or drains.

318. Penalty for not preventing child under 12 from committing nuisance in street, Rs. 5. (Repealed by Madras Act III of 1888.)

319. Public latrines and urinals to be provided by President.

Sect. 321. Penalty of Rs. 50 and Rs. 10 per day for allowing any building or land, after notice from the President, to remain in a filthy or unwholesome state or overgrown with noxious vegetation.

322. Power to enter and order cleansing of buildings.

323. When obstruction is caused to drainage, ventilation, or cleansing, by crowding together of buildings, the President may require necessary works to be done or buildings to be pulled down.

324. The President may obtain an order from a Magistrate to abate overcrowding in buildings.

325. Injurious wells or stagnant pools must be drained or filled up or cleaned, wells to be filled up only with clean soil.

326. In the case of private tanks or wells owner may be required to do this.

328. Watering of streets.

335. Livery stables, cart-stands, cattle yards, etc., must be licensed.

336. Penalty of Rs. 10 and Rs. 5 per day for keeping pigs so as to be a nuisance.

337. Stray pigs may be destroyed.

343. Bake-houses must be licensed, also ice and aerated water factories.

345. Commissioners must provide slaughter-houses.

346. Slaughter-houses must be licensed.

347. License required and fee for each animal slaughtered.

352. Commissioners may provide markets.

354. And make bye-laws for their regulation.

359 *et seq.* private markets must be licensed and be properly kept.

367. Power of entry to examine articles of food or drink and to detain them if unwholesome. Magistrate may order them to be destroyed, and owner is liable to be prosecuted under section 273, Indian Penal Code.

368. Every medical practitioner who treats or knows of any epidemic, endemic, or dangerous infectious disease, except in a public hospital, must notify it to the President or to the Health Officer.

369. Power of entry to prevent spread of disease.

370. Carriages for conveyance of patients may be provided.

371. Power of removing to hospital patient suffering from dangerous infectious disease, who is without proper lodging or who is lodged in a room occupied by more than one family.

Sect. 372. Power to order disinfection of buildings, or articles at expense of owner, or in case of owner's inability, of municipal fund.

373. Disinfecting apparatus may be provided, also places for washing infected articles, and such articles may be destroyed with or without compensation.

374. Penalty of Rs 50 for giving, lending, selling or transmitting infected articles.

375. Similar penalty for person suffering from a dangerous infectious disease who enters or is conveyed in a public vehicle without proper precaution.

377. Penalty of Rs. 200 for letting infected rooms.

378. The Governor in Council may notify that vaccination is compulsory under approved bye-laws.

379. Burial and burning grounds must be registered.

381. And a list of them be published annually.

388. When dangerous to health may be closed.

390. Graves must be 5 feet deep with not less than 2 feet between them; a corpse must be buried within 6 hours after being brought to burial ground; old graves must not be re-opened without leave; burning must be begun within 6 hours after a body is brought to burning ground; cremation must be complete and cloths must be burnt; corpses carried through street must be decently covered and not left on high-way; under a penalty of Rs. 50.

392. Commissioners to provide burial or burning grounds.

394. Commissioners must keep register of births and deaths and appoint registrars

397. Every registrar shall inform himself of and register every birth and death in his district.

398. Information of every birth to be given within a week by the father or mother, or in case of their death or inability, by some one who was present or in attendance at the birth.

399. Information of death to be given, within 24 hours, by some one who was present or in attendance, or in default by the occupier or some person living in the house.

401. Persons performing funeral to give information.

402. Rs. 20 penalty for neglect.

404. Sum not exceeding As. 4 may be given to informer.

413. Power to make bye-laws.

414. Which must be confirmed by Government.

The Madras District Municipalities Act (1884).*

Sect. 113. The funds raised under this Act are applicable to the following purposes :—

(i) Construction and maintenance of streets, bridges, and other means of communication ;

(ii) Maintenance of hospitals, dispensaries, asylums, markets, drains, sewers, water-works, tanks, wells, training of medical practitioners and vaccinators, sanitary inspection of towns and villages, registration of births and deaths, lighting and cleansing of streets, and other works of a similar nature ;

(iii) Diffusion of education, maintenance of schools wholly or by grants-in-aid, training of teachers ;

(iv) Other measures of public utility to promote safety, health, comfort, or convenience of people ;

(v) and (vi) Payment of salaries and expenses.

32. The Chairman is the chief executive officer of the Municipal Council.

33. The Collector of the district may execute any resolution on default of the Chairman.

34. The Collector has inspecting powers.

35. The Government or the Collector may suspend action.

75. Water-tax on buildings and lands.

125. Provision and maintenance of hospitals and dispensaries.

129. Provision for gratuitous vaccination.

133. Government may declare vaccination compulsory.

134. When every child over six months and under ten years of age must be vaccinated.

138. Penalty of Rs. 50 and Rs. 10 a day for disobedience of notice to have child vaccinated.

142. Prohibition of inoculation. Penalty of 3 months' imprisonment or fine of Rs. 200 or both.

143. Municipal Council shall, so far as funds admit, provide a sufficient supply of water fit for domestic use.

144. The Council may, with the sanction of Government, construct new works, and may maintain, close, or alter existing works.

---

* The Act supersedes the Towns Improvement Act, 1871.

Sect. 152. Penalty of Rs. 500 and Rs. 100 a day for fouling water by offensive trades.

154. Council may set apart tanks, wells, etc., for drinking purposes, and for bathing and washing animals or clothes.

155. Penalty for fouling drinking-water sources, public or private in any way, Rs. 20.

156. Power to require private well, tank, stream, etc., to be cleaned and kept in order or to be closed, if unfit for drinking.

157. Maintenance and repair of streets.

175. Watering and lighting streets.

179 Before a new building is erected application must be made with a statement of dimensions, level for foundations and ground floor, means of ventilation, drainage and privies, and such other particulars as may be required. If disapproved of Municipal Council to state their views.

186. Council may require filthy buildings or lands to be cleansed, and lands overgrown with noxious vegetation to be cleared. In default work may be done at owner's expense.

187. Power to require buildings crowded together in an insanitary way to be altered or pulled down, or to execute such work.

188. Licenses for offensive or dangerous trades, cattle yards to contain 10 head of cattle or pigs, or 20 sheep or goats, public stables, etc., and bake-houses.

191. Municipal Council to provide slaughter-places or houses. Slaughter-houses and butchers' shop must be licensed and license-fees charged for all animals slaughtered.

192. Penalty for slaughtering elsewhere or drying skins so as to cause nuisance, Rs. 20.

194. Municipal Council may provide markets.

196. Private markets may be licensed.

206. Municipal Council shall, so far as funds admit, provide and maintain a sufficient number of public latrines and urinals.

207. Owner or occupier of a building or of ground on which a block of six or more huts stands, may be required to provide or alter and properly maintain a latrine.

208. Latrine must be provided when more than 20 labourers are employed.

209. Power to contract for private scavenging.

210. Drainage works to be constructed under the direction of Municipal Council.

Sect. 213. No drain, privy or cess-pool shall be constructed without permission of Council.

214. Branch drains, private latrines, cess-pools, etc., to be under the control of Council and kept in order at cost of owners.

216. Cleansing of streets.

217. Providing rubbish dépôts and dust-bins. Fine of Rs. 10 for deposit elsewhere.

218. Providing covered vehicles and dépôt for night-soil. Similar fine for deposit elsewhere.

219. Provision of moveable temporary receptacles in houses if required.

221. Penalty of Rs. 20 and Rs. 5 a day for keeping filth more than 24 hours on premises and for neglecting to keep latrine in proper order.

222. Penalty of Rs. 10 for allowing sewage to flow into street.

224. Penalty of Rs. 20 for throwing rubbish into sewers.

225. Penalty of Rs. 5 for not preventing child under 12 from committing nuisance in street.

226. Municipal Council may take proceedings to prevent overcrowding im buildings. Penalty of Rs. 10 a day for neglect of Magistrate's order.

227. Power to cleanse or fill up stagnant pools or wells.

228. Owners may be required to cleanse, fence, repair or fill up tank or well or drain of stagnant water.

230. Stray pigs and dogs may be destroyed.

231. Power of entry to prevent spread of disease, and to disinfect houses and articles at owner's or at Municipal expense.

232. Places for washing infected articles may be appointed or such articles may be destroyed. Penalty for washing elsewhere, Rs. 50.

233. Chairman may, on a medical certificate, order removal to hospital of patients without proper accommodation or lodged in a room occupied by more than one family.

234. Municipal Council to provide burning or burial grounds.

235. Burning and burial grounds to be registered.

238. Penalty for disposing of corpse elsewhere, Rs. 100.

241. Same as 390 of Madras Municipal Act.

243. Municipal Council to keep register of births and deaths and appoint registrars.

247. Father or mother or some one present at birth to give information within a week. Some one present at death, or in attendance during illness, or

occupier of house, to give information of death within 24 hours.*

Sect. 255. The Municipal Council is empowered to make bye-laws which must be confirmed by Government.

THE MADRAS LOCAL BOARDS' ACT, 1884.

District Boards,† Taluk Boards and Panchayats have been constituted by this Act for the purposes of local Government, including village and district sanitation.

144. Government may, from time to time, make rules as to the duties, responsibilities and mutual relations of those bodies.

The following is a brief account of the constitution of Local Boards and Panchayats as formed under this Act.

District Boards.

Authority over each district is vested in a District Board, which consists of a President and at least 24 members. The Collector is *ex-officio* President, unless Government has authorized the election of the President; and every revenue officer in charge of a division is a member. The other members may all be appointed by Government or be in part elected; but not more than one-fourth may be officials.

Taluk Boards.

The local authority of each taluk is a Taluk Board, which is in a manner subordinate to the District Board. The revenue officer in charge of the division of the district in which the taluk is situated is *ex-officio* President, unless Government has authorized the election of the President. The Board must consist of at least 12 members, who may be appointed wholly by Government or partly by election. Not more than one-third may be officials. Meetings must be held at least once a month. A Board may be abolished by order of Government. The President of a Local Board is its chief executive officer.

Panchayats.

Any village or group of villages may, from time to time, be constituted a *union* by notification of Government. *Major unions* have a population over, *minor unions* under, 5,000. Each union is controlled by a *Panchayat* of not less than five members. The headman of each village in a union is *ex-officio* a member. The other members may be appointed by Government or be in part elected. Government may appoint a Chairman or authorize his election.

---

* It is noticeable that no penalty for default is contained in the Act, though such was provided in the Local Boards Act, 1871. But, under section 255 of the present Act, a bye-law may provide a penalty of Rs. 50.

† District Boards take the place of the Local Fund Boards of the Local Funds' Act, 1871.

A Panchayat is the agent of and under the control of the Taluk Board.

Duties of Local Boards.

Sect. 95. Every Local Board shall, so far as funds admit, provide for :—

- (i) the construction and maintenance of streets, bridges, and other means of communication ;
- (ii) the planting and preservation of trees by roads and on public places ;
- (iii) the construction and repair of hospitals, dispensaries, markets, drains, sewers, water-works, tanks, wells, training of medical practitioners and vaccinators, sanitation of towns and villages, and other works of a similar nature ;
- (iv) education, school-houses, maintenance of schools wholly or by grants-in-aid, inspection of schools, training of teachers ;
- (v) relief works in famine or scarcity ;
- (vi) other measures of public utility to promote safety, health, comfort or convenience ;
- (vii) and (viii) payment of salaries and expenses.

98. The President of the Taluk Board may cause obstructions and encroachments to be removed.

99. Private sources of drinking water may be cleansed, fenced or closed.

101. Unwholesome buildings or lands may be cleansed or drained. In default of the owner this is to be done at the expense of the Taluk Fund.*

102. District Board to provide for gratuitous vaccination.

106. Government may proclaim vaccination compulsory in any district from a specified date.

107. All unprotected children over 6 months and under 10 years of age must then be vaccinated.

112. Penalty of Rs. 50 and Rs. 10 a day for disobedience of Magistrate's order to have child vaccinated.

117. President of Taluk Board may contract for private scavenging.

Duties of Panchayats.

141. In all unions—

- (*a*) Cleansing the village streets, drains, tanks, wells, and other public places in the union ;
- (*b*) generally doing such things as may be necessary for the preservation of public health.

---

* Some amendment appears to be needed here.

In a major union—

(*a*) making and repairing the village streets and drains in the union:

(*b*) constructing and repairing such tanks and wells and other works as will supply the inhabitants of the union with sufficient water for domestic use.

INDIAN PENAL CODE.

(*Act XLV of 1860 amended by Act VIII of 1882.*)

CHAPTER XIV. *Of offences affecting the public health, safety, convenience, decency and morals.*

268. A person is guilty of a public nuisance, who does any act, or is guilty of an illegal omission, which causes any injury, danger or annoyance to the public or to the people in general who dwell or occupy property in the vicinity, or which must necessarily cause injury, obstruction, danger or annoyance to persons who may have occasion to use any public right.

A common nuisance is not excused on the ground that it causes some convenience or advantage.

269. A negligent act likely to spread the infection of any disease dangerous to life is punishable by 6 months' imprisonment, which may be with hard labor, or by fine, or both.

270. A malignant act likely to spread the infection of any disease dangerous to life is punishable by 2 years' imprisonment, which may be with hard labor, or by fine, or both.

271. Disobedience to a quarantine rule punishable by 6 months' imprisonment, or fine, or both.

272. Adulteration of food or drink intended for sale, so as to make it noxious, is punishable by imprisonment for 6 months, or a fine of Rs. 1,000, or both.

273. Sale of noxious food or drink (knowingly) is punishable by similar penalties.

274. Adulteration of drugs so as to lessen their efficiency or change their operations or make them noxious carries similar penalties.

275. Sale of adulterated drugs or (276) of any drug as a different drug or preparation is similarly punishable.

277. Fouling the water of a public spring or reservoir* is punishable by 3 months' imprisonment, or fine of Rs. 500, or both.

---

* This does not include a river.

Sect. 278. Making atmosphere noxious to health is similarly punishable.

284. Negligent conduct with respect to any poisonous substance is punishable by 6 months' imprisonment, or fine of Rs. 1,000, or both.

290. Punishment for public nuisance (in any case not otherwise punishable by this Code), fine up to Rs. 200.

291. Continuance of nuisance after injunction to discontinue is punishable by six months' imprisonment, or fine or both.

CODE OF CRIMINAL PROCEDURE (*Act V of 1885*).

Sect. 54. Any police officer may, without an order from a Magistrate, and without a warrant, arrest any person who has been concerned in any cognizable offence, or against whom a reasonable complaint has been made, or credible information has been received or a reasonable suspicion exists, of his having been so concerned.

Public Nuisances.

Sect. 133. A conditional order for the removal of a nuisance, obstruction, or injurious trade, may be made by a District, Sub-divisional or duly empowered First-class Magistrate.

135. Person to whom order is addressed must obey it, or show cause against doing so, or apply to the Magistrate for a jury to try it.

136. On default person is liable to penalty under section 188, Penal Code, and order shall be made absolute.

140. When an order has been made absolute the person is to be required to perform the act within a given time; on default he is liable to penalty by section 188, Penal Code.

If such act is not performed within the time fixed, the Magistrate may cause it to be performed, and may recover the cost from the person.

142. To prevent imminent danger or injury of serious kind to the public, a Magistrate making an order under section 133 may issue such injunction as may be required. In default he may adopt such means as he thinks fit to prevent it.

143. A Magistrate may order any person not to repeat or continue a public nuisance, as defined in the Indian Penal Code or any special or local law.

Sect. 144. An absolute order may be at once issued in urgent cases of nuisance.

149. Every police officer shall interpose to prevent the commission of any cognizable offence.

151. If necessary, he may arrest without warrant to prevent commission of any such offence.*

155. Non-cognizable offences can only be investigated by, or under orders of, a Magistrate.

---

* Cognizable offences under Penal Code, sections 269, 277, 291.

APPENDIX A.

Comparison of English and Metrical Weights and Measures.

1 metre = 39·37 inches.
1 millimetre = ·03937 inches.
1 inch = 2·54 centimetres.
1 mile = 1·6093 kilometres.
1 square metre = 10·76 square feet.
1 litre = 1·0 cubic decimetre.
= 1,000·0 cubic centimetres.
= 61·025 cubic inches.
= 35·3 fluid ounces.
1 cubic foot = 1,000·0 fluid ounces.
= 6·23 gallons.
1 cubic metre = 35·316 cubic feet.
1 gram = 15·43 grains.
1 kilogram = 2·2 pounds avoirdupois.

To convert the centigrade thermometric scale to the Fahrenheit scale, multiply by $\frac{9}{5}$ and then add 32. To convert Fahrenheit to centigrade, subtract 32 and then multiply by $\frac{5}{9}$.

APPENDIX B.

A list of some of the offensive trades carried on in the Madras Presidency which require to be licensed. The main points to be looked to in deciding whether these places are fit to be licensed are detailed in a memorandum issued by the Sanitary Commissioner to all Chairmen of Municipalities.

Oil boiling.
Oil mills.
Camphor boiling.
Bone boiling.
Paddy boiling.
Indigo dyeing.
Bone dépôts.
Salt fish dépôts.
Tanneries.
Skin godowns.
Arrack distilleries.
Paper factories.
Slaughter-houses.
Public cattle-yards.
Hack stables.
Pig keeping.
Chemical works.

Working with poisonous metals. Any manufacture in which noxious gases are evolved or foul waste liquors are discharged.

Businesses which should be licensed and kept under close observation by the Sanitary authorities.

Markets, private.
Cattle-yards, private.
Bakeries.
Sweetmeat bazaars.
Aërated water factories.
Ice factories.
Cart stands.
Meat stalls.
Dhobi houses and washing places.
Hotels and eating houses.

All places where any kind of food material intended for public consumption is stored, prepared or exposed for sale.

Dangerous trades which are licensed, but do not necessarily come under the control of the Sanitary department.

Firework Factories.
Wood dépôts.
Kerosine-oil stores.
Explosives stores.

INDEX.

A

Ablution, 152.
Act, The City of Madras Municipal, 257.
  ,, The Code of Criminal Procedure, 268.
  ,, The District Municipalities (Madras), 262.
  ,, The Indian Penal Code, 267.
  ,, The Madras Local Boards, 265.
Actinomyces, 180.
Adulteration of food, 46.
Aërated water, 90.
Age, distribution of population, 234.
Air, 91.
  ,, composition of, 91.
  ,, cooling of, 102.
  ,, impurities in, 92.
  ,, effects of impure, 94.
  ,, examination of, 102.
  ,, organic matter in, 93, 95.
  ,, purification of, 95.
  ,, quantity required, 97.
Air space, cubic, 98.
  ,, superficial, 98.
Albumenoid ammonia, 87.
Alcohol, 35, 36, 159.
Alluvial soil, 128.
Altitude and climate, 135.
  ,, measurement of, 139.
Alum, 68.
Amaranth, 27.
Ammonia, 87.
Analysis of air, 102.
  ,, water 80.
Ancient hygiene, 2.
Anchylostoma, 172, 175.
Anemometer, 138, 140.
Animal foods, 29.
Animals, communicable diseases, 178.
Annual rates, 230.
Anopheles, 206.
Anthrax, 46, 178.
Aqueducts, 73.
Arrangement of statistics, 231.
Ascaris, lumbricoides, 172.
Ata, 27.
Averages, 228.
Average strength, 230.

B

Bacteria, 179.
  ,, in air, 93.
  ,, in water 69, 88.
  ,, in soil, 124, 131.
Bajra, 24, 26.
Barometer, 139.
Bathing, 152.
  ,, places, 149.
Beans, 27, 39.
Beer, 35.
Berkefeld filter, 71.
Beverages, 34.
Bilharzia hæmatobia, 176.
Biological purity of water, 67.
Biolysis of sewage, 117.
Birth rates, 243.
Bladder worms, 172, 174.
Blood, 32.
Blood worm, 172, 174.
Boiling, 67, 201.
Bowel diseases, 219.
Brackish water, 55.
Bread, 49.
Broad irrigation, 116.
Brush-wood, 129.
Building regulations, 141, 148.
  ,, sites, 142.
Buildings, public, 147.
Burial of the dead, 121.
Burning the dead, 121.
Butter, 31.
Butter milk, 32.

C

Carbolic Acid, 202.
Carbonaceous food, 12.
Carbohydrates, 13.
Carbon dioxide, 91.
Catchment area, 65.
Catch-pits, 114.
Cattle yards, 149.
Causes of death, 252.
Cellulose, 14.
Census, 234.
Cereal grains, 23.
Chamberland filter, 71.

Chemical disinfectants, 201.
Chicken-pox, 222.
Children, care of, 153.
Chloride of lime, 202.
Chlorine, 87, 201.
Cholam, 24, 25, 26.
Cholera, 210.
Classification of diseases, 8, 168.
Clark's process, 68.
Cleanliness, personal, 152.
Cleansing, 107.
Clearing-nut, 68.
Climate, 17, 22, 131.
Clothing, 72, 153, 204.
Cloud, 136, 138.
Code of Criminal Procedure, 268.
Coffee, 34.
Color of clothes, 155.
Color, poisonous, 155.
Collection of water, 65.
Combined system of sewers, 107.
Communicable diseases, 184.
Compulsory notification, 196.
Condiments, 14.
Conjugal condition, 160, 238.
Consanguine marriage, 162.
Consumption (phthisis), 222.
Constant supply of water, 74.
Conservancy, 110.
Constituents of soil, 123.
,, of food, 12.
Contagion, 183.
Contagious Diseases Act, 223.
Contagium, 183.
Continence, 163.
Cooking, 25, 41.
Cooling of air, 101.
Corrected death-rate, 250.
Corrosive sublimate, 202.
Cotton clothing, 154.
Cow-dung on walls, 145.
Cream, 31.
Cremation, 121.
Cubic space, 104.
Cultivation of soil, 129.
,, wet, 131.
Culex, 207.
Curds, 31.
Current steam, 201.
Custom, 151.

D

Damp Proof Course, 144.
Death, causes of, 252.
,, rates, 247.
,, ,, infantile, 250.
Deep wells, 58.
Deficiency of food, 22.
Density of population, 240.
Deodorants, 200.
Dextrin, 14.
Dew-point, 133.
Dhal, 27.
Dhobies, 72, 153.
Diarrhœa, 219.
,, infantile, 219.
Diet, 15, 17, 37.
Digestibility, 42.
Disease, 17, 20, 56, 155.
Disinfection, 200.
Disposal of dead, 121.
,, rubbish, 108.
,, sewage, 115.
Distillation, 67.
District Boards, 265.
Domestic filters, 70.
Drainage, 112, 113, 129, 209.
Dry earth system, 110.
Dry Heat, 200.
Dust, 93.
Duration of life, 254.
Dysentery, 219.

E

Early Marriage, 160, 238, 246.
Earth, *see* Soil.
Eating, excessive, 158.
Echinococcus, 172.
Economic value of health, 5.
Ectozoa, 171.
Education, 150, 151, 159, 238.
Eggs, 30.
Elephantiasis, 174.
Endemic disease, 186.
Energy, source of, 136.
Enteric fever, 220.
Entozoa, 171.
Epidemic disease, 186.
,, preparation, against, 4.
Epizootic diseases, 188.
Evaporation, 102.
Examination of water, 80.
Excess of food, 23, 158.
Excreta, 109, 198.
Excretion, 169.
Exercise, 20, 155.
Extremes as a test of means, 228.

F

Famine-infants, 164.
Fats, 13, 32.
Female education, 151.
Fermentation, 9.

Fermented liquor, 35.
Fever, malarial, 205.
,, enteric, 220.
,, relapsing, 222.
,, sun, 133.
Filaria sanguinis hominis, 172.
,, medinensis, 172, 176.
Filth, removal of, 110.
Filtration, 69.
Filters, domestic, 70.
,, sand, 70.
Fish, 30, 66.
Flies, 185.
Floors, 143, 145.
Flour, 49.
Flukes, 52, 171.
Food, 11.
,, preservation of, 43.
,, inspection of, 47.
Foot-tons, 20, 157.
Formaldehyde, 201.
Fruits, 33, 40, 49.
Free ammonia, 87.
Function of nitrogen, 14.

G

Ganjah, 159.
Ghi, 32.
,, adulteration of, 46.
Grain, 48.
Gram, 28.
Grass, 117, 129.
Ground air, 124.
,, floor, 143.
,, nut, 29, 46.
,, water, 125.
Guinea worm, 172, 176.
Gundli, 26.

H

Habit, 17, 22, 150.
Haffkine, 190, 191.
Hardness of water, 55, 68, 73, 87.
Health, 1.
Heat, 132.
Hemp, Indian, 159.
Herbage, 129.
Hereditary disease, 163.
Hill climate, 134.
Hospitals, infectious, 197.
Houses, 141.
House latrines, 111.
Humidity of air, 91, 138.
Humus, 123, 131.
Hydatid, 172, 174.
Hygrometry, 138.

I

Ice, 90.
Ignorance and Sanitation, 6.
Immunity, 182.
Impurities in air, 92.
,, water, 54.
Incinerators, 109.
Incubation period, 177.
Indian Penal Code, 267.
Infancy, 164.
Infantile diarrhœa, 219.
,, Mortality, 250.
Infant marriage, 160.
Infants, care of, 164.
Infection, avoidance of, 195.
Infectious diseases, 168.
,, ,, hospitals, 197.
Infectivity, period of, 199.
Inferences from examination of water, 84.
Infiltration galleries, 65.
Infirmities, 239.
Inhabited houses, 240.
Inoculation, 190, 215.
Interiors, house, 146.
Intermittent downward filtration, 117.
,, supply of water, 74.
Insects as carriers of disease, 94, 185, 206, 221.
Inspection of food, 47.
Intemperance, 158.
Irrigation, 113, 116, 118, 209.
Isolation of sick, 192, 197, 213, 215.
Itch, 174.

J

Jigger flea, 173.
Joar, 24, 26.

K

Kambu, 24, 26.
Kangu, 24, 26.
Kerosine oil, 209.
Kidney disease, 208.
Koch, 210.
Koda, 24, 26.

L

Lactation, prolonged, 164.
Latrines, private, 111.
,, public, 111.
,, village, 119.
,, water-carriage, 113.
Law, Sanitary, 256.
Lead in water, 73.
Leather, 155, 201.
Legislation, 256.

Leguminosæ, 15, 27.
Lentil, 28.
Leprosy, 224.
Lice, 173.
Life duration, 254.
,, tables, 254.
Light, 136, 137.
Lime, slaked, 203.
Linen, 154.
Liquid excreta, 109.
Local conditions, 123.
Local examination of water, 81.
Longevity, 166.

M

Maida, 27.
Made soil, 128.
Malaria, 205.
Manson, 206.
Marching, 157.
Markets, 148.
Marriage, 160, 238.
Materials, clothing, 154.
Maternity, 164.
Meals, 42.
Means, 228.
Measles, 52, 222.
Measurement of altitude, 139.
,, of cubic space, 104.
,, of rain water supply, 77.
,, of storage tank, 78.
,, of superficies, 104.
,, of wells and streams, 79, 80.
Meat, 30, 51.
Mechanical value of food, 20.
Mental hygiene, 159.
Meteorology, 137.
Microbes, 8, 177, 179.
Microbic diseases, 177.
Microscopic examination of water, 82.
Milk, 31, 50, 213.
Millets, 26.
Moisture, 91, 133.
Moist heat, 201.
Monogamy, 160.
Mortality, *see* Deaths.
Mosquitoes, 143, 206.

N

Natural purification of water, 66.
New buildings, 148.
Night soil, *see* Latrines and Ordure.
Nitrogenous food, 11, 12, 13.
Nitrates, 85, 87, 88.
Nitrites, 85.
Nitrifying bacteria, 111, 116, 118, 131.
Nitrogen, 14, 91.
Nitrous acid, 201.
Nocturnal radiation, 138.
Norton's tube well, 64.
Notification, 196.
Nuisances, public, 267, 268.
Nursing, 164.
Nuts, 34.

O

Objections to sanitation, 6, 7.
Occupation, 236, 253.
Oil-inunction, 152.
Oils and fats, 13, 32.
Old age, 166.
Opium, 159.
Ordure, 109.
Organic matter in air, 95.
,, ,, soil, 129.
,, ,, water, 69, 84
Out-houses, 146.
Overcrowding, 240.
Oxygen, 91.
Ozone, 91.

P

Pail system for latrines, 110.
Pancháyats, 265.
Parasites, 10, 46, 52, 56, 152, 170.
Parsi, disposal of dead, 121.
Pasteur, 191.
Pasteur-Chamberland filter, 71.
Pathogenic microbes, 180.
Peas, 27.
Percentages, 226.
Perchloride of mercury, 202.
Permanent hardness, 87.
Personal hygiene, 150.
Persons, disinfection of, 204.
Phthisis, 222.
Physical examination of water, 82.
Physiology of food, 11.
Phosphoric acid, 88.
Plague, 221.
Plans, 148.
Plinth, 143.
Population, 233.
Potassium permanganate, 69, 203.
Poudrette, 111.
Poverty, 4.
Pregnancy, 164.
Preparation of food grains, 25, 26, 28.
Preserved foods, 44.
Pressure of air, 134, 138.
Prevention of disease, 1, 3, 157, 168.
Privies, *see* Latrines.
Proportions of diet, 15.

Protective inoculation, 190
Proteids, 13.
Public buildings, 147.
,, health, 5.
,, latrines, 111.
Pulses, 28.
Pumps, 64.
Punkahs, 101.
Purification of air, 101.
,, sewage, 116.
,, water, 67.

Q

Quantity of food, 19.
Quarantine, 193.
Quinine, 208.

R

Radiation, Solar, 137.
,, terrestrial, 138.
Ragi, 26.
Rain, 136, 139, 140.
,, gauge, 140.
,, water, 57, 59.
Rations, 36.
Ratios, 226.
Registration of Births and Deaths, 242.
Relapsing fever, 222.
Removal of waste, 106.
Respiration, 95.
Re-vaccination, 218.
Rice, 25.
River water, 61.
Roofs, 145.
Rooms, disinfection of, 203.
Round worms, 172, 175.
Ross, 206.

S

Salts in food, 13, 41.
Sand filter, 70.
Sanitary Law, 256.
Schools, 147.
Scurvy, 40.
Sea quarantine, 195.
Seasonal mortality, 253.
Separate system of sewers, 106.
Septic tank, 118.
Sewage, 106, 113, 115.
Sewage-farming, 116.
Sewers, 106, 114, 203.
Sex constitution of population, 236.
Sexual abuse, 163.
Shallow wells, 62.
Sherbet, 34.
Sick, isolation of, 192, 197.
Sickness, 254.
Side drains, 114.
Silk, 154.
Silt, 115.
Sites, 142.
Skin, cleansing of, 152.
,, diseases, 173.
Slaked lime, 203.
Slaughter-houses 148.
Small-pox, 214.
Smoking, 159.
Social customs, 151.
Soil, 123.
Solar radiation, 137.
Solid excreta, 109.
Space, cubic, 97, 104.
,, superficial, 98, 104.
Spirilla, 179, 180.
Spirit rations, 36.
Spirits, 35, 158.
Sporadic disease, 186.
Spores, 180.
Sporozoite, 206.
Spring water, 58.
Stables, 146.
Staple grains, 23.
Starches, 13.
Statistics, 225.
Steam, 201.
,, disinfector, 201.
Stegomyia, 207.
Storage tanks, 66.
Street sweepings, 107.
Strength, average, 230.
Strychnos potatorum, 68.
Sub-soil, 123.
Sub-soil water, 57, 125.
Suckling, 164.
Sugar, 14, 33.
Suji, 26.
Sulphur dioxide, 201.
Sun, 136.
Surface water, 61.
Susceptibility to disease, 182.
Syphilis, 223.

T

Taluq Boards, 265.
Tank water, 58.
Tape-worms, 46, 52, 172, 174.
Tatties or mats, 101.
Tea, 34.
Temperance, 36, 158.
Temperature, 132, 138.
Terrestrial radiation, 138.
Thermantidotes, 101.
Thermometers, 137, 139.
Thread-worms, 172.

Thrush, 180.
Tobacco, 159.
Toddy, 35.
Total hardness of water, 87.
,, solids ,, 87.
Towns, sanitation of, 241.
,, water-supply of, 71.
Training, physical, 157.
,, of children, 150.
Trees, 129, 208.
Trenching, 112.
Trichina spiralis, 46, 52, 172.
Tuberculosis, 222.
Typhoid fever, 220.
Tyre, 31.

U

Uncorrected population, 228, 233.
Unhealthy soils, 127, 129.
Upland surface water, 58.
Upper floors, 145.
Urinals, 119.

V

Vaccination, 191, 215.
Value of analysis of water, 89.
Varagu, 24, 26.
Variety in diet, 41.
Vegetables, 33, 40, 49.
Vegetation, 129.
Ventilation, 97.
Verandahs, 145.
Village latrines, 119.
Vitality, 157, 166.
Vital statistics, 225.

W

Walls of houses, 143.
Washing, clothes, 72.
Wastage of water, 72.
Waste, removal of, 106.
Waste of food, 42.
Water-supply of villages, 75.
,, ,, towns, 71.
Water vapour, 91, 133.
,, carriage system, 112.
Water-proof clothes, 155.
Waters, aërated, 90.
Weaning children, 165.
Wells, 57, 58, 61, 62.
Wet cultivation, 131, 209.
Wheat, 26.
Wind, 99, 135, 138.
Women, education of, 151.
Woollen clothing, 154.
Work, 17, 20, 155.
Worms, 171.
Wright, 190.

Y

Yield of water from rain, 77.
,, ,, ,, wells and streams, 79, 80.
Youth, 16, 165.

Z

Zygote, 206.

WELLCOME LIBRARY INSTITUTE